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UNIVERSITY OF NOTTINGHAM

REPORT OF THE SCHOOL OF AGRICULTURE

1961

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REPORT OF THE SCHOOL OF AGRICULTURE

1961

SUTTON BONINGTON
LOUGHBOROUGH
LEICESTERSHIRE
1962

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INTRODUCTION

THE UNIVERSITY OF NOTTINGHAM SCHOOL OF AGRICULTURE

THE School of Agriculture in its present form came into being in 1947 with the transfer to the University College of Nottingham of the buildings and land at Sutton Bonington held by the former Midland Agricultural College. This College had its origin in the Department of Agriculture (founded in 1893) of the University College of Nottingham and in the Midland Dairy Institute (founded in 1895). These were combined in 1900 to form the independent Midland Agricultural and Dairy Institute, whose title was changed in 1906 to that of the Midland Agricultural College. For the first 30 years of its existence the principal function of the College remained the provision of certificate and diploma courses in Agriculture, Dairying and Poultry Husbandry. Collaboration between the Midland Agricultural College and the University College of Nottingham led in 1943 to the establishment of a Faculty of Agriculture and Horticulture and this was followed four years later by the transfer of the College to the University, which received its Charter in 1948.

The School of Agriculture, consisting of the four University Departments of Agriculture, Agricultural Sciences, Horticulture and Agricultural Economics, is situated at Sutton Bonington, 10 miles south of the City of Nottingham, and lies between 100 and 250 feet above sea level in gently undulating country adjacent to the valley of the River Soar. The estate extends to about 600 acres, of which 300 are arable. Two farms are operated, one for demonstration and one for experimental purposes, the remainder of the land being occupied by the Department of Horticulture Demonstration Unit, ornamental and sports grounds and buildings. The buildings comprise: a central block in which are located lecture rooms, a library, common rooms, laboratories for the Agricultural Microbiology section and administrative offices; halls of residence and a refectory; a dairy which is one of the largest in the country used for teaching purposes; two large houses—" The Elms," converted for the use of the Agricultural Zoology section, and " St. Michael's," occupied by the Department of Agricultural Economics; and a new Agricultural Sciences building.

This last building, completed in 1959, accommodates the Agricultural Botany and Agricultural Chemistry sections of the Department of Agricultural Sciences and the Animal Physiology and Crop Husbandry sections of the Department of Agriculture. Facilities are provided for postgraduate and honours students in the above sections and for labora-

tory teaching in all subjects, except Microbiology, of the B.Sc. degree course. The building is equipped with service facilities for research, including cold rooms, constant temperature rooms, plant growth rooms, a small-animal house, a radio-isotope laboratory, preparation rooms, a hydrology laboratory, spectrographic and X-ray analysis laboratories, a photographic studio and a workshop. A Field Demonstration Unit comprising, *inter alia*, a grass garden, nutrition plots and lysimeters is being developed adjacent to the laboratories, and nearby are located experimental glasshouses, a number of which are insect-proof for entomological work. The School maintains an "agro-met" meteorological station and also keeps records of incoming solar radiation.

The Department of Agriculture consists of three sections—Crop Husbandry, Animal Husbandry and Animal Physiology, each with differing requirements for research and teaching. An Experimental Farm of some 200 acres provides facilities for research. These include a slaughterhouse and cold room, rooms for metabolism and digestibility studies with cattle, sheep, pigs and poultry, a room for work with radioactive isotopes and a field laboratory. Accommodation, modified to permit individual or group feeding depending on the nature of the investigation, is available for pigs, sheep, laying hens and broiler chickens, and for a dairy herd mainly of identical twins. Some 60 breeding sows are maintained, some 9,000 head of poultry, 40 dairy cows with followers, and a breeding ewe flock. In addition to the land required for research in crop and grassland husbandry, facilities are provided on the Experimental Farm for the regional crop variety trials of the National Institute of Agricultural Botany. Some 300 acres based on Manor Farm, Kingston, are farmed separately to demonstrate farm management and crop and animal production, the major enterprises being a herd of 55 Friesian dairy cattle and their followers, a Masham ewe flock for lamb production and arable cropping. A Demonstration Hall is available for teaching Farm Mechanisation and there is a fully equipped engineering workshop for the maintenance of machinery.

In the Department of Horticulture there are facilities for teaching and research work. The Demonstration Unit includes about an acre of heated and unheated glasshouses, successive plantings of young fruit trees on a variety of rootstocks to illustrate the problems concerned in building up productive cropping units, an established orchard of pears and apples, and small areas of vegetables, frames and cloches. There is also a collection of hardy and tender plants of horticultural and botanical interest. Facilities for research on various aspects of the effects of weather on the growth and yield of plants include the largest installation of evapotranspiration gauges in the United Kingdom for use in detailed

studies of soil/plant/water relations; there are also several series of plots in which plants can be subjected to different, definable and reproducible water-regimes and where daily measurements can be made of the amount of water used. Ten growth rooms, some of unusually large size, are used for growing temperate or tropical plants under controlled environmental conditions of light and temperature.

The Department of Agricultural Economics, as well as being a department of the University, is a part of the Provincial Agricultural Economics Service for England and Wales and is responsible to the Ministry of Agriculture, Fisheries and Food for the supply of economic data about agriculture in the East Midlands. It is also responsible for advisory and extension work in farm management throughout the East Midlands Province.

The objectives of the School are twofold: to enlarge the stock of knowledge relating to Agriculture in its widest sense, and to disseminate it by means of undergraduate and postgraduate courses. The University of Nottingham maintains at the School courses of instruction for the degree of B.Sc. and candidates admitted to such courses may qualify for honours degrees in Agronomy, Agricultural Botany, Agricultural Chemistry, Agricultural Microbiology, Agricultural Zoology, Animal Production or Horticulture, or for general honours and pass degrees in Agriculture, Food Science or Horticulture. The course leading to a Diploma in Dairying will cease in 1963. Enrolment for the current year included 181 students for first degree courses, 20 students for the diploma course and, excluding Demonstrators and Research Assistants, there are 46 postgraduate students.

Apart from the Department of Agricultural Economics, extension work in agriculture is not a function of the School, although some is effected through visits of Young Farmers' Clubs, parties of farmers and other visitors to the experimental and demonstration fields and to the laboratories, and by lectures given by members of the staff to farmers' and growers' organisations and other bodies. During the period under review members of staff have continued to co-operate with the British Broadcasting Corporation in providing programme material for Sound and Television services.

The scientific work of the School centres around the study of the principles of crop and animal husbandry, and of the problems which may be associated with them. Expressed in more precise terms the aim is to conduct researches on soil, plant and animal problems relating to agricul-

ture and horticulture and on the insect pests which affect production. Certain aspects of the work in progress, which has reached a stage suitable for review, are described in a later part of this report.

This research work is mainly financed from general University funds, but in recent years investigations have been aided by grants from other organisations to whom grateful acknowledgement is made.

During 1961 the Department of Horticulture continued to receive support from the Agricultural Research Council to the extent of £3,088 for the development of specific research on the water relations of plants and the use of chemical regulators. £1,000 was donated by Messrs. Whiffen and Sons and Fisons for the continuation of the study of plant responses to weather. A grant of £2,000 was also made by the Leverhulme Trust Fund to finance an interchange of five post-graduate students between the Departments of Horticulture of the Universities of Nottingham and Khartoum.

Generous support towards the prosecution of experimental work has been received by the Department of Agriculture in the form of grants, gifts and assistance from Boots, Bibbys, B.O.C.M., Fisons, Johnson and Johnson, National Chemical Products Ltd., Robirch, J. Sainsbury, Schering Co., Spillers and T. Wall & Sons. The grant from an anonymous donor to develop experimental facilities for work with poultry and pigs has continued. Support from the Pig Industry Development Authority for studies on pig nutrition, the British Egg Marketing Board for poultry nutrition and the Agricultural Research Council for potato investigation has continued. The Sugar Beet Research and Education Committee has provided funds for research with sugar beet. Numerous manufacturers have loaned equipment and machinery for demonstration and teaching and several farmers in the East Midlands have kindly provided facilities for experimental work with livestock. Grateful thanks are expressed to the companies and individuals concerned.

Borax Consolidated have continued their annual grant to the Agricultural Sciences Department of £500 for studies on the role of boron in plants and Genatosan have continued to support, by a grant of £900, work on the amino-acid requirements of farm animals. The Agricultural Research Council has provided £550 p.a. for an investigation on dormancy and apical dominance of the potato and continued support for studies in poultry nutrition will amount this year to £1,976; Messrs. T. Hedley have provided £250 for studies on the utilisation of fats; the Sugar Beet Research and Education Committee has made a grant of £600 p.a. for studies on the growth of sugar beet; and the Nature Conser-

vancy has provided £550 p.a. for investigations on Festuca-Lolium hybrids. The Egg Marketing Board has provided an annual grant of £1,860 for the Departments of Agricultural Sciences and Agriculture. The African Pyrethrum Board has provided an additional grant to cover the cost of part-time technical assistance for the African Pyrethrum Fellow; it has also agreed to provide £145 towards the cost of cooling equipment for the insecticides laboratory. Work on the biochemistry of the legumes has been supported by the Nuffield Foundation with a further instalment of the three-year grant of £4,450 made in 1958. An annual grant of £300 for a period of three years has been received from the Pig Industry Development Authority to support work on pig nutrition. Gifts and assistance from Fisons, Pfizer, Bourbon Products, Spillers, National Chemical Products, Bush, Beach and Segner Bayley, Baywood Chemicals Ltd., and the Midland Counties Dairies are also gratefully acknowledged.

THE UNIVERSITY OF NOTTINGHAM

Chancellor:
His Grace the Duke of Portland, K.G., LL.D.

Vice-Chancellor:
Bertrand Leslie Hallward, D.L., M.A.

Deputy Vice-Chancellor:
Professor Harry Raymond Pitt, B.A., Ph.D., F.R.S.

Dean of the Faculty of Agriculture and Horticulture:
Professor Frederick Leon Milthorpe, M.Sc.Agr., Ph.D., D.I.C.

Registrar:
Alfred Plumb, M.A.

Secretary to the School of Agriculture:
David Frederick Rex, B.A., LL.B.

SCHOOL OF AGRICULTURE ADVISORY COMMITTEE

Alderman Sir Francis Hill, C.B.E., M.A., LL.M., Litt.D., LL.D.
Mr. B. L. Hallward, D.L., M.A.
Mr. G. D. Bailey, J.P.
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Professor D. K. Britton, B.Sc. (Econ.), M.A.
Mr. H. Burtt
Mr. R. M. Chambers, B.Sc., B.Agr.
Professor C. G. C. Chesters, M.Sc., Ph.D.
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Mr. G. B. Drummond
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Mr. R. B. Ferro, N.D.A.

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Sir John Hammond, C.B.E., M.A., D.Sc., F.R.S.

Mr. J. F. D. Hargreaves

Mr. C. L. Hempsall

Mr. C. E. Horton, C.B.E., M.A.

Professor J. P. Hudson, M.B.E., G.M., M.Sc., Ph.D., N.D.H.

Professor J. D. Ivins, M.Sc. (Agric.), Ph.D.

Alderman F. J. Jenkinson, O.B.E., J.P.

Mr. P. Lyth, B.Sc.

Professor F. L. Milthorpe, M.Sc.Agr., Ph.D., D.I.C.

Mr. P. A. Missen, M.A., Dip. Agric.

Professor H. R. Pitt, B.A., Ph.D., F.R.S.

Mr. R. S. C. Readman, B.Sc.

Mr. J. W. Rowland, N.D.A., N.D.P.

Mr. B. Savage

Alderman T. W. Scholey

Councillor J. L. Shelton

Mr. E. F. R. Stearn, M.A., M.Sc.

Alderman G. E. Taylor, C.B.E., M.A., J.P.

Mr. J. B. Thomas

Alderman A. Thompson

Sir James Scott Watson, C.B.E., M.C., LL.D., D.Sc.

THE UNIVERSITY OF NOTTINGHAM
SCHOOL OF AGRICULTURE

STAFF

DEPARTMENT OF AGRICULTURAL SCIENCES

Professor of Agricultural Chemistry and Head of Department:	E. G. Hallsworth, B.Sc., Ph.D. (Leeds), A.R.I.C.
Agricultural Chemistry:	
Reader:	D. Lewis, M.A. (Cambridge), M.Sc. (Wales), Ph.D. (Sheffield)
Senior Lecturer:	E. R. Ling, M.Sc. (London), Ph.D. (Nottingham), A.R.C.S., F.R.I.C.
Lecturers:	
Soil Chemistry	D. V. Crawford, M.A., B.Sc. (Oxford), Ph.D. (Nottingham)
Biochemistry	G. Norton, B.Sc., Ph.D. (Nottingham)
Soil Physics	I. R. Cowan, M.Sc. (London)
Assistant Lecturers:	
Biochemistry	P. E. Cansfield, B.Sc. (Wales)
Soil Physics	I. F. Taylor, B.Sc. (London)
Nuffield Research Fellow:	[1] I. H. Rorison, M.A., D.Phil. (Oxford)
Demonstrator:	S. B. Wilson, B.Sc. (Nottingham)
Research Assistants:	[2] C. P. Freeman, B.Sc. (Birmingham)
	[3] G. H. Smith, B.A. (Cambridge)
	[4] H. S. Bayley, B.Sc. (Reading)
	B. Cartwright, B.Sc. (Wales)
Agricultural Botany:	
Professor:	F. L. Milthorpe, M.Sc.Agr. (Sydney), Ph.D. (London), D.I.C.

[1] Resigned September, 1961.

[2] Resigned August, 1961.

[3] Financed by Messrs. Genatosan.

[4] Financed by the Pig Industry Development Authority.

Lecturers:

Agricultural Botany	K. W. Dent, B.Sc., Ph.D. (Birmingham).
	Miriam M. Edwards, M.Sc., Ph.D. (Manchester)
Plant Pathology	[5] T. H. Nicolson, B.Sc. (Agric.) (Aberdeen), Ph.D. (Nottingham)
Genetics	W. J. Whittington, B.Sc. (Wales), Ph.D. (Nottingham)
Assistant Lecturer:	B. G. Lewis, B.Sc. (Bristol)
Demonstrator:	W. M. Dean, M.Sc. (Manchester)
Research Assistants:	[6] Elizabeth M. Ingersent, B.A. (Oxford)
	[7] C. R. Slack, B.Sc. (Nottingham)
	[8] P. B. Goodwin, M.Sc.Agr. (Sydney)
	[9] Pamela M. Shaw, B.Sc. (Wales)
	[10]N. Terry, B.Sc. (Southampton)

Agricultural Microbiology:

Reader:	M. Woodbine, M.Sc., Ph.D. (Manchester), F.R.I.C.
Lecturer:	A. Seaman, B.Sc. (London), Ph.D. (Nottingham)
Demonstrator:	P. J. Harris, M.Sc. (Nottingham)

Agricultural Zoology:

Lecturers:	P. W. E. Murphy, B.Agric.Sc. (N.U.I.), D.Phil. (Oxford)
	J. Y. Ritchie, B.Sc. (Agric.) (Glasgow)
African Pyrethrum Research Fellow:	W. N. Yule, B.Sc. (Glasgow)

[5] Resigned March, 1961.

[6] Resigned July, 1961.

[7] Financed by Borax Consolidated Ltd.

[8] Financed by the Agricultural Research Council.

[9] Financed by the Nature Conservancy.

[10] Financed by the Sugar Beet Research and Education Committee.

Demonstrator:	[11]M. L. Jerath, M.Sc. (Punjab), Ph.D. (Oregon)
	D. J. L. Harding, B.A. (Cambridge)
Dairying:	
Lecturer:	M. Stein, J.U. Dr. (Prague), B.Sc., Ph.D. (Leeds)
Departmental Assistants:	Frances L. Buckley, N.D.D., S.D.P.H.
	[12]Rosemary J. Prince, B.Sc. (Reading)
Food Science:	
Lecturer:	E. J. Rolfe, B.Sc. (London), F.R.I.C.

DEPARTMENT OF AGRICULTURE

Professor of Agriculture and Head of Department:	J. D. Ivins, B.Sc. (Reading), M.Sc. (Agric.), Ph.D. (Nottingham)
Reader in Animal Physiology:	G. E. Lamming, B.Sc. (London), M.S., Ph.D. (Illinois), N.D.A. (Hons.)
Senior Lecturer:	[13]J. T. Morgan, M.Sc. (Wales), Ph.D. (Nottingham), A.R.I.C.
Lecturers:	
Agricultural Engineering	J. Chatterton, D.F.C., B.Sc. (London), M.Sc. (Nottingham)
Animal Husbandry	G. A. Lodge, B.Sc. (Durham), Ph.D. (Aberdeen)
	C. G. Payne, B.Sc. (Nottingham), Ph.D. (London)
Crop Husbandry	P. M. Bremner, B.Sc. (Edinburgh), M.S. (Cornell), Dip. Agric. (Cambridge).
Part-time Lecturer:	
Farm Buildings	P. J. M. Aston, M.A. (Cambridge), A.R.I.C.S., Q.A.L.A.S.

[11] Resigned February, 1961.

[12] Resigned July, 1961.

[13] Resigned May, 1961.

Honorary Lecturers:	
Veterinary Hygiene	J. C. Buxton, B.Sc., Ph.D. (Nottingham), M.R.C.V.S.
	Connie M. Ford, M.R.C.V.S.
Fison Research Fellow:	R. D. Harkess, B.Sc. (Edinburgh), M.S. (Cornell).
British Egg Marketing Board Junior Research Fellow:	Joy Stevens, M.Sc. (Manchester)
Departmental Assistant:	D. B. Crighton, B.Sc. (Agric.) (Glasgow), M.Sc. (Edinburgh)
Demonstrators:	R. L. Hall, B.Sc. (Nottingham).
	J. H. D. Prescott, B.Sc. (Nottingham)
Research Assistants:	[14]R. W. Radley, B.Sc. (Nottingham)
	[15]D. W. Robinson, B.Sc. (Nottingham)
National Institute of Agricultural Botany Regional Trials Officer:	J. C. Llewelyn, B.Sc. (Wales), S.D.A. (Hons.).

DEPARTMENT OF HORTICULTURE

Professor of Horticulture and Head of Department:	J. P. Hudson, M.B.E., G.M., B.Sc. (Hort.), M.Sc. (London), Ph.D. (Nottingham), N.D.H.
Lecturers:	Margaret E. Marston, B.Sc. (London), M.Sc. (Hort.), Ph.D. (Nottingham), N.D.H.
	W. Heydecker, B.Sc. (Hort.) (Reading), M.Sc., Ph.D. (Nottingham), N.D.H. (Hons.)
	Winifred M. Dullforce, M.Sc. (Nottingham), N.D.H.
Temporary Assistant Lecturer:	W. R. Buckley, M.Sc. (London)
Research Assistant:	[16]D. V. Clay, B.Sc. (London).

[14] Financed by the Agricultural Research Council.

[15] Financed by the Pig Industry Development Authority.

[16] Financed by Messrs. Whiffen and Sons Ltd.

DEPARTMENT OF AGRICULTURAL ECONOMICS

Professor of Agricultural Economics and Head of Department:	D. K. Britton, B.Sc. (Econ.) (London), M.A. (Oxford)
Senior Agricultural Economists:	R. B. Jones, M.Sc. (Wales)
	W. S. Senior, B.Sc. (Agric.) (Leeds)
Agricultural Economists:	R. O. Wood, M.Sc. (London)
	K. A. Ingersent, B.Sc. (Aberdeen), M.S. (Minnesota)
	T. K. Warley, B.Sc. (Hort.), M.Sc. (Nottingham)
	G. E. Jones, B.A. (Manchester), B.Litt. (Oxford)
Assistant Agricultural Economists:	[17]H. G. Evans, B.Sc. (Wales)
	Margaret M. Sandilands, B.A. (London)
	T. W. D. Theophilus, B.Sc. (Wales)
	M. E. Daw, B.Sc. (Nottingham), N.D.A.
Research Assistants:	[18]K. E. Hocknell, M.Sc. (Nottingham)
	Margaret Loadman, B.Sc. (Nottingham)
	J. A. H. Nicholson, B.Sc. (London)

ADMINISTRATION

Secretary to the School of Agriculture:	[19]H. Harris, B.Sc. (Econ.), LL.B. (London), D.P.A., F.C.C.S.
	D. F. Rex, B.A. (Bristol), LL.B. (London)
Senior Tutor:	[20]J. T. Morgan, M.Sc. (Wales), Ph.D. (Nottingham), A.R.I.C.
	W. J. Whittington, B.Sc. (Wales), Ph.D. (Nottingham)
Librarian:	Nancy W. Rhodes, B.A. (London), A.L.A.
Administrative Assistant:	Muriel I. Wood
Clerk of Works:	A. W. Turner
Chief Technician:	F. C. Treeby

[17] Resigned November, 1961.
[18] Resigned September, 1961.
[19] Resigned October, 1961.
[20] Resigned May, 1961.

FULL-TIME POST GRADUATE STUDENTS*

	Subject	Degree
J. F. Ainsworth, B.A. (Cambridge)	*Agricultural Chemistry*	M.Sc.
G. D. Anagnostopoulos, B.Sc. (Athens)	*Agricultural Microbiology*	M.Sc.
A. N. Balla, B.Sc. (Agric.) (Khartoum)	*Agricultural Zoology*	M.Sc.
S. W. Burrage, B.Sc. (Nottingham)	*Agricultural Botany*	Ph.D.
F. J. Burrows, B.Sc. (Nottingham)	*Agricultural Botany*	Ph.D.
R. L. Burt, B.Sc. (Reading)	*Agricultural Botany*	Ph.D.
D. R. Cullimore, B.Sc. (Nottingham)	*Agricultural Microbiology*	Ph.D.
J. L. Davidson, M.Ag.Sc. (Agronomy) (Adelaide)	*Agricultural Botany*	Ph.D.
K. G. Drake, B.Sc. (London)	*Crop Husbandry*	M.Sc.
A. H. El Rayah, B.Sc. (Agric.) (Khartoum)	*Agricultural Botany*	M.Sc.
A. K. E. S. El Saeed, B.Sc. (Agric.) (Khartoum), M.S. (Agric.) (California)	*Crop Husbandry*	Ph.D.
J. Gilmour, B.Sc. (Reading)	*Agricultural Botany*	M.Sc.
D. Gunary, B.Sc. (Nottingham)	*Agricultural Chemistry*	Ph.D.
D. W. Hand, B.Sc. (Reading)	*Horticulture*	M.Sc.
H. U. Hasnain, B.V.Sc. (Panjab)	*Animal Physiology*	M.Sc.
J. M. Hopkinson, B.Sc. (Nottingham)	*Agricultural Botany*	Ph.D.
M. A. Hossain, M.Sc. (Dacca), Postgraduate Diploma (Genetics) (Edinburgh)	*Agricultural Botany*	Ph.D.
H. Idris, B.Sc. (London)	*Agricultural Botany*	M.Sc.
P. C. Jain, B.Sc. (Agric.) (Delhi), M.Sc. (Ag.) (Agra)	*Horticulture*	Ph.D.
J. B. Krause, B.S. (Agriculture), M.S. (Animal Science) (Illinois)	*Animal Physiology*	Ph.D.
M. S. Manohar, B.Sc. (Ag.) (Rajasthan), M.Sc. (Ag.) (Agra)	*Horticulture*	M.Sc.
G. Marincowitz, B.Sc. (Agric.), M.Sc. (Agric.) (Pretoria)	*Animal Physiology*	Ph.D.

* Excluding Research Assistants and Demonstrators.

	Subject	Degree
J. E. M. Mordue, B.Sc. (Bristol)	*Agricultural Botany*	Ph.D.
W. E. Peat, B.Sc. (Nottingham)	*Agricultural Botany*	Ph.D.
S. Pickworth, B.Sc. (Reading)	*Animal Physiology*	Ph.D.
A. F. Rainbow, B.Sc. (Nottingham)	*Agricultural Botany*	M.Sc.
C. I. M. Reekie, B.Sc. (Agr.) (McGill)	*Agricultural Economics*	M.Sc.
M. M. Saad, B.Sc. (Agric.), M.Sc. (Cairo)	*Agricultural Economics*	Ph.D.
J. A. T. Saul, B.Sc. (London)	*Agricultural Chemistry*	Ph.D.
A. G. Schaffer, M.Sc. (London)	*Agricultural Chemistry*	Ph.D.
R. K. Scott, B.Sc. (Nottingham)	*Crop Husbandry*	Ph.D.
J. W. Slater, B.Sc. (Nottingham)	*Agricultural Botany*	Ph.D.
J. R. Syme, B.Sc. (Sydney)	*Crop Husbandry*	Ph.D.
M. A. Taha, B.Sc. (Agric.) (London), Dip. Agric. (Khartoum)	*Crop Husbandry*	Ph.D.
M. J. Turner, B.Sc. (Nottingham)	*Animal Physiology*	Ph.D.
H. O. Uwaegbute, B.Sc. (Nottingham)	*Agricultural Chemistry*	Ph.D.
P. D. Waister, B.Sc. (Edinburgh)	*Horticulture*	Ph.D.
T. G. Wood, B.Sc. (Durham)	*Agricultural Zoology*	Ph.D.
M. G. Yates, B.Sc. (Wales)	*Agricultural Chemistry*	Ph.D.

PART-TIME POST GRADUATE STUDENTS

	Subject	Degree
F. G. Clegg, B.Sc. (Edinburgh), M.R.C.V.S.	*Animal Physiology*	M.Sc.
E. T. Gibbons, B.Sc. (Econ.) (London)	*Agricultural Economics*	M.Sc.
D. G. A. Guttridge, M.Sc. (Nottingham)	*Animal Husbandry*	Ph.D.
K. N. Harris, B.Sc. (Edinburgh), M.Sc. (Nottingham)	*Agricultural Microbiology*	Ph.D.
I. V. Herbert, B.Sc. (Nottingham), M.S. (Iowa)	*Agricultural Zoology*	Ph.D.
M. Jalil, M.Sc. (Ag.) (Agra)	*Agricultural Zoology*	M.Sc.
A. J. Smith, B.Sc. (Nottingham)	*Animal Husbandry*	M.Sc.

RESEARCH IN THE SCHOOL OF AGRICULTURE

The problems under investigation can be classified in the following categories:

(a) Soil topics, including investigations into the nature and distribution of soil types, the processes responsible for their formation, and their relationships with physical factors;

(b) The nature of plant growth, such as internal correlations and genetic influences, and the influence of external factors, such as light, temperature, water, mineral nutrients, cultural practices, and competition;

(c) Animal growth and production, particularly with reference to grassland, the effect of nutrition, and the level and effect of hormones;

(d) Microbiological influences on plant or animal health or on the utilization of agricultural products;

(e) Chemical aspects of the utilization of agricultural products;

(f) Problems associated with insects and other invertebrates;

(g) Farm management and returns in relation to the national economy and specific investigations in Agricultural Economics.

Brief reports of investigations in each of these fields are given below and fuller accounts of certain selected topics follow.

Soil Studies

Work on the mechanism of podzolisation has continued, especially on the biological side, but so far it has been impossible to associate the effects observed with mixed cultures of B-horizon organisms with one of the individual species commonly isolated from podzols. The study of the immobilization process is being extended to include nitrogen and carbohydrates present in the extracts employed. Differential thermal analysis has been used to examine the clays present in the farm soils which are found to be predominantly illitic, with no signs of kaolinites. The movement of phosphorus into crumbs from various soils and under different conditions has been examined with considerable success, using a combination of thin-section and autoradiographic techniques. The method promises to explain some anomalies in the use of ^{32}P for measuring the labile pool of soil phosphorus. A preliminary spectographic examination of different types of so-called manganese concretions occurring in local soils has revealed the accumulation of cobalt, copper and possibly other trace elements in them. The nature and formation of these concretions is being studied to try to discover the mechanism of their growth.

Plant Growth

Investigations in the Agricultural Chemistry section on the copper and cobalt nutrition of subterranean clover plants grown in sand and water culture have been continued. Copper has been shown to be accumulated in the roots. Much of this is adsorbed on the surface, but about one-third of the total is in the free space of the root and can be readily washed out again. The continuing concentrations of copper found in the roots of plants receiving high levels of copper is not paralleled by the quantity transferred to the leaves, which appears to stabilise at a level characteristic of the level of supply. Leaf analysis suggests that plants whose leaves contain less than 5-7 p.p.m. of copper are on a deficient level of supply. The results of further increase in copper supply suggests that the nodule and the plant are alternative sinks for copper, and that appreciably higher concentrations are required in the leaves before any effect is seen on nodule development. Studies of the effect of copper and cobalt on the metabolism of subterranean clover are continuing, with particular attention to the amino and carboxylic acids, and the polyphenols and haem compounds. Using radio-active carbon as a label, it has been possible to show that increasing the level of copper supplied to the plant results in an increase in the glutamic acid and alanine contents of the nodule. Part of this work has been reported elsewhere. Some investigation has also been made of the trace element requirements of Rhizobia as free-living organisms, and it has been confirmed that, at appropriate levels of cobalt supply, the bacteria can synthesize vitamin B_{12}. It has been found that within the nodule most of the cobalt is present as B_{12}, but one fraction, at present unidentified, appears to be different.

Studies have continued on the biochemistry of iron chlorosis using lupin as test species. Because of the complexity of the problem emphasis has been shifted from the study of whole plants to detached leaves, which should permit an investigation of the deficiency effects long before growth has been affected and before visual symptoms become obvious. One of the first effects of Fe deficiency is an increased respiratory rate when glucose is supplied as external substrate. Preliminary experiments using ^{14}C labelled sugars suggest that oxidative pathways not present in normal plants may be developed.

Experiments on the effects of aluminium toxicity on metabolism have yielded some interesting leads. The growth of *Lupinus luteus*, which is almost a calcifuge, is unaffected by high aluminium levels in nutrient solutions, but the preliminary analysis of whole plants indicates that A1 is having an effect on the metabolism of the plant. Using whole

plants of calicole species such as sainfoin, organic analyses indicate that metabolism is greatly affected and experiments are in progress to study the effects of Al on the metabolism of root tips. Preliminary experiments have shown that Al affects oxygen uptake of sainfoin roots within one hour, while lupin roots are unaffected even after three hours.

Studies on the role of boron in plant growth have continued in the Agricultural Botany section. As bean roots become deficient in boron, their rates of elongation decrease gradually to zero. This follows a cessation of cell division which may be associated with changes in cell-wall structure. Lack of boron in elongating cells leads to increased cellulose synthesis and decreased pectin synthesis with a simultaneous accumulation of sugars and amino-acids. There is no evidence for a current hypothesis that deficiency symptoms result because the transport of sugars is prevented. In a continuation of the study of leaf growth of cucumber, measurements of photosynthesis and respiration by infra-red gas analysis, dry weight increase and translocation from intact leaves have been made. From these the course of import, export, fixation and utilization of carbon and the import and export of phosphorus during the lives of individual leaves have been estimated. Another experiment has shown that senescence of leaves is much hastened by shading. The results of these and earlier defoliation and shading experiments are being used to explore the degree of variation between leaves at different nodes and in different environments which may be attributed to direct nutritional influences. The effect of various substances on expansion of leaf disks is being explored.

Work has continued on the inheritance of growth rate in tomatoes. The F_1 and F_2 generations from half a diallel cross derived from *Lycopersicon pimpinellifolium* and three varieties of *L. esculentum* were grown, the growth rates being analysed genetically. *L. pimpinellifolium* had the highest growth rate, there being little difference between the other three parents. The F_1 hybrids, particularly those involving *L. pimpinellifolium*, had a growth rate slightly higher than that of either parent, suggesting over-dominance in the characters controlling growth rate, or inter-allelic interaction.

Experiments have been carried out to investigate the influence of night temperature on the growth and tuberization of the potato plant. The effect of exposing the whole plant and the roots and shoots separately to night temperatures of 15° and 25°C and of 12° and 22°C has been investigated. Tubers were initiated first when the whole plant was subjected to the lower night temperature and there was little difference between subjecting either roots or shoots to the lower

night temperature. Tubers were initiated within 8 weeks when part or the whole of the plant was kept at 22°C but not when kept at 25°C. Influences on tuber initiation were closely associated with differences in the growth pattern of the haulm (degree of axillary branching, leaf area, etc.); it is suggested that night temperature influences tuber initiation by modifying the use of carbohydrate and mineral elements (and thereby influencing their concentration in the stolon tips) rather than by producing a specific tuber-forming substance. The photoperiodic aspect of tuber formation has been studied, plants being grown under three light intensities at two daylengths. Tubers formed earlier in short than in long days with any one total amount of daily radiation. At any one daylength, increase in intensity (and total radiation) shortens the time to tuber initiation. The concentrations of auxin and other substances in stolon tips during tuber initiation are being determined. A series of studies on sprout growth of the potato has been completed and is reported elsewhere in this Report. These studies are being continued with a detailed investigation of dormancy and of apical dominance. The influence of time of lifting, method of storage and location (Edinburgh, Sutton Bonington and Efford) on sprout growth and subsequent ware production is also being investigated.

In the potato crop the effects of seed size and spacing, and of irregularities therein, continue to receive attention in the Department of Agriculture, and an account of the work appears elsewhere in this Report. This investigation is being extended to include a study of the factors responsible for reduced yield per plant at closer spacings. The time of planting investigations have shown that mid-April is the optimum planting time for maincrops in this area; earlier planting, whilst increasing the risk of frost damage, fails to increase yield. With earlies, the effects of earlier tuber initiation associated with early planting may be offset by a lower bulking rate and earlier senescence of foliage, but these latter effects assume importance only with late lifting of earlies. Preliminary investigations indicate that the application of fertilisers (particularly N) delays tuber initiation, and that whilst at moderate levels of application an increased bulking rate more than compensates for this, at high levels there is further suppression of tuber formation, without a compensating increase in bulking rate, leading to lower yields as compared with moderate fertiliser levels.

Cereal work includes a study of competition in oats/barley mixtures, this being an attempt to explain the frequently observed increase in yield associated with mixtures as compared with "straight" crops. Results, so far, suggest that this increase in yield may result only under certain environmental conditions, and this will be investigated further.

The study of ear development in relation to yield in winter wheat continues. Since grain number is determined primarily by the number of carpels at anthesis, and since results suggest that carpel size at this time may affect final grain size, factors affecting carpel numbers and size are being investigated. Studies of seed size in winter wheat have shown the effects on early plant development of seed size to be a function of endosperm size rather than embryo size. Investigations on continuous wheat cropping are still in progress.

Work on sugar beet has started, and projects in hand include: the importance of leaf development in relation to yield; the importance of competition for light; the effects of irrigation and nitrogen on growth and development and yield of sugar beet at different population levels; and the effect of sodium on growth and development. In the Agricultural Botany section a detailed study of the effect of light and temperature on the growth of sugar beet has commenced.

The dormancy of charlock (*Sinapis arvensis*) (cf. Ann. Report for 1958) can be broken by treating the seeds with 2,000 p.p.m. gibberellic acid for 24 hr. This effect and its relation to the oxygen economy of the seeds are being examined.

A series of experiments is being conducted to determine the relative importance of various factors controlling the rate of regrowth of cocksfoot (*Dactylis glomerata*) following defoliation. Studies over short periods immediately following defoliation indicate that temperature has a major influence and light intensity has no effect. It appears that the so-called "reserve" carbohydrates influence the initial rate of regrowth and that different types of carbohydrate are probably involved. Further experiments aim at specifying the carbohydrates concerned, assessing their quantitative importance, and at elucidating their contribution to regrowth over a longer period. Some studies on *Lolium perenne* indicate that light intensity during regrowth, and the initial amount of growing material after defoliation play a more significant role than "reserve" materials in the growth made over periods of 2-3 weeks.

A detailed study via growth analysis, of the influence of the management of grassland in the autumn on the spring growth of herbage is in progress and also the relationship between nitrogen supply and the spring growth of Italian Ryegrass is being investigated.

The establishment and survival of sterile hybrids between *Festuca pratensis* and *Lolium perenne* under different systems of management is being analysed, particular attention being given to the number and sizes of "survival" organs and differences in growth of the hybrids and their parents.

The relative roles of light and nutrients in the competition between barley and charlock is being investigated, including an attempt to analyse in detail both the light and nutrient environments of the component plants.

Investigations on the quantitative changes in the stomatal conductance of potato and sugar beet under English conditions have commenced. It has been estimated that sugar beet has a stomatal population of 12,900 and 19,900/cm^2 on the upper and lower surfaces respectively and a *maximum* conductance of 14 cm./cm^2 leaf.

In the Department of Horticulture work continues on the effects of different water regimes on the growth and yield of tomato and lettuce plants grown under glass, and on the rates of water loss under a range of evaporating conditions. It has been confirmed that a simple type of evaporimeter can be used under glass to give a close estimate of evapotranspiration rates, despite the generally unsatisfactory performance of evaporimeters when used in the open. Evapotranspiration rates of plants grown in the open are also being studied, using a series of gauges of a pattern developed in the Department, with a view to ascertaining the magnitude of edge effects in plots used for irrigation experiments where there is a difference in height between plants in different treatments. This work has been extended to include a study of similar questions under the intense evaporating conditions that occur in an arid area in the Sudan, where the Head of the Department of Horticulture is spending part of his time on secondment to the Faculty of Agriculture, University of Khartoum.

Problems of seedling establishment in different soils are being further investigated, with special reference to the question of seedling vigour. Short periods of excessive or inadequate moisture conditions in the seedbed are found to have considerable effects on both establishment and further growth of some seedlings.

Work on a tropical drug plant of economic importance has continued in a series of large growth rooms. The environmental conditions under which the plants will grow satisfactorily and produce the required alkaloid have now been established and work is proceeding to ascertain the most rapid and reliable methods of propagating this species.

Pieces of root or leaves of certain species regenerate and produce new plants when placed in suitable environmental conditions, providing a useful method of obtaining a large number of new plants from limited material. Factors which influence the rate of regeneration of progeny, and the number produced from each piece of plant material, are being

investigated. Experimental work with detached leaves of *Streptocarpus*, grown in nutrient solutions with varying nitrogen levels, indicates that fewer but larger progeny are produced at the higher levels. Work has continued on the growth and development of the raspberry plant (*Rubus idaeus*) in controlled environments. The vegetative shoot normally exhibits two distinct growth forms in response to various combinations of temperature and daylength, but these responses can be modified by chemical treatments. For instance, the application of gibberellic acid to rosetted plants causes elongation to occur whereas, in contrast, quaternary ammonium compounds applied to actively growing plants inhibit further elongation and result in the formation of leafy rosettes. Gibberellic acid and quaternary ammonium compounds, when applied together, are found to be antagonistic in their effects. Work continues on the effects of environmental factors on the growth and development of glasshouse lettuce varieties. The pattern of growth and development, particularly in relation to hearting, is being analysed and the results related to those obtained previously under controlled conditions of light and temperature.

Animal Growth and Production

The departments of Agriculture and Agricultural Sciences are collaborating in a research programme concerned with the nutrition of pigs and poultry where the major objective is to define more accurately the dietary requirements of these classes of livestock. Attention is also being given to the efficiency with which certain foods are able to satisfy those requirements. The assessment of the optimum is not made solely in terms of liveweight changes but also directly in terms of the appropriate productive characteristic. Thus, particular attention is being given to the bacon pig, the broiler chicken and the laying hen.

A continuing investigation is being made of the nutrition of pigs destined for both "Wiltshire" bacon and "Heavy" trade. The performance of the pigs under different circumstances of energy-protein ratio is assessed in terms of live weight increase, food conversion ratio and efficiency of nitrogen utilization. It has been demonstrated that provided good amino acid balance is maintained in the ration a satisfactory performance is achieved with relatively low protein. It has also been firmly established that higher protein level is directly associated with lean content of the carcass. The digestible energy of individual cereals has been measured in the pig using a balance-calorimeter procedure. The supplementation of high-nitrogen barley with individual amino acids has shown that excellent performance can be achieved provided the

amino acid inadequacies of the barley are corrected. The work upon the role of fats in pig nutrition has continued and the digestibility of individual fats and fatty acids has been measured. This has emphasised the significance of faecal fats not of immediate exogenous origin; such as microbial fats, fats of endogenous origin, and fatty acids resulting from hydrogenation in the alimentary tract. A feeding trial is being conducted with fats included in the ration and replacing part of the 'energy': lower protein-energy ratios in 'finisher' rations are achieved by increasing energy rather than reducing protein. The effects of implantation with androgens and new synthetic steroids on the performance of pigs is also being studied. The experiments are designed in two parts—metabolism work to check the effects of the materials on nitrogen retention in male pigs, and more extensive feeding experiments to assess the influence of these materials on growth rate and feed conversion ratio of male and female pigs. Assessment of carcass quality is made via carcass dissection throughout these investigations. Initial work on the nutrition of the sow is designed to assess the effects on reproductive performance of varying planes of feeding during pregnancy and lactation. A covered yard to accommodate 60 sows with facilities for individual feeding is being built to permit this work to develop further. Experiments are also planned to study the influence of lactation on the reproductive activity of the sow and to expand work already completed in other species, on the influence of ovarian hormones on composition of uterine secretions in the sow.

The part played by arginine in the intermediary metabolism and nutrition of the chick is receiving continued attention. The distribution and kinetic properties of arginase and glycine transamidinase have been studied. It is recognised that arginine is an essential amino acid for the chick but that the optimum dietary level seems to vary with the overall amino acid composition of the ration. It has been established that provided a good amino acid balance is maintained the dietary requirement for arginine can invariably be satisfied by any standard ration of the type used in commercial practice in the United Kingdom. A technique has been developed for the determination of the pigments of egg yolk. The effects of added synthetic pigments, of unsaturated fatty acids and of anti-oxidants, are being examined. A large experimental broiler unit is now available to house 72 units each of up to 100 birds and here the examination of optimum levels of dietary energy and protein at various stages of growth is being continued. Several types of fat have been used and the growth performance measured when protein is fed at different levels. In each case every effort was made to supply amino acids balanced in relation to apparent requirements. It is recognised

that problems are encountered if no regulation is made of the feeding and management of broiler breeding stock. The birds may become over-fat and there is precocious achievement of reproductive maturity. An experimental procedure has therefore been devised to restrict protein and/or energy in association with a programme of lighting designed to delay the onset of sexual maturity. The live weight and food consumption of the birds is measured and the quantity and quality of subsequent egg production will be recorded. An empirical examination is being made of the dietary requirements of hybrid laying hens. The effect of including substances alleged to contain unidentified growth factors is being measured and the optimum protein content of fat supplemented rations is being determined.

Considerable attention is being given to the determination of the biological availability of amino acids to the chick. A procedure has been devised based upon measurement of live weight gain in chicks following graded supplementation of a basal ration containing inadequate methionine and cystine. The procedure is being extended to include a bio-assay of lysine using a basal ration containing sesame meal. The nitrogen balance will also be determined. By using these values as a guide of adequacy of amino acid balance a procedure is being developed to determine ideal amino acid requirements.

Studies have been initiated in which it is attempted to separate the effects of each of the components of the climatic environment on poultry production. In the first instance chicks have been reared in climatic chambers with various levels of added ammonia and the effects on health and performance have been studied. A concentration of 100 parts per million of ammonia in the atmosphere led to a depression of some 20% in growth rate of chicks between the ages of five and eight weeks. This stresses the importance of ventilation and other factors of management of intensively housed poultry.

For some years on the Experimental Farm production from grassland has been measured in terms of milk yields, live weight gains and utilized starch equivalent but the results have been biased and on occasion determined by grazing pressure, rate of stocking, stage of lactation and other factors of animal management. It was concluded that trials using these techniques measured only the value of a particular herd on a particular pasture and in an endeavour to establish a method of grassland evaluation which was independent of animal and management variables, interest centred on the extent to which grass, either fresh or conserved, is digested by the animal, the object being

to express grassland output in terms of yields of digestible organic matter. It was found that dairy cows of different breeds, ages, weights and levels of milk production digested similar herbage to the same extent, whereas these variable animal factors had marked effects on the evaluation of pasture by more conventional methods. No significant differences were found in the digestibility of similar samples of herbage when tested by dairy cows or wether sheep over several trials. Reduction of feed intake by 50 per cent led to a significant but slight (3-4 per cent) increase in the digestibility of herbage assessed by both cattle and sheep. This suggests the need for standardisation of levels of feeding in digestibility trials, although the effect may be of little practical importance where widely differing issues are investigated. There appears to be a clear relationship between the digestibility of herbage and the quantities consumed by the animal and also between herbage digestibility and levels of animal production. Characteristics of the herbage, such as species, stage of growth and age, influence the digestibility of herbage and work is proceeding on the effects of sward-type and management on herbage digestibility and total yields of digestible organic matter. In particular the contribution of white clover is being investigated.

Attention is continuing to be given to the methods available for characterizing the fibrous and carbohydrate constituents of animal foods. A method giving improved separation and estimation has been developed, and will be published elsewhere. It has been confirmed that changes in the starch content of the diet may affect the butterfat content of the milk, and studies are continuing to determine, by the use of gas-liquid chromatography, whether there is any concomitant change in the distribution of the individual fatty acids. The long-term experiment on effect of various levels of roughage during rearing on the subsequent ability of the cow to utilise roughage for milk production is continuing.

Experiments on the use of ^{14}C-oestrone in sheep have continued and have shown that the vast majority of injected material is excreted very rapidly, mainly via the faeces. A study is being made of the extent and site of any radio-activity remaining in the carcass. Work on the use of hormones to induce extra-seasonal breeding activity in lactating sheep has been expanded. In one flock of sheep, used in 1961 for experiments, 125 extra-seasonal lambs were produced from 95 sheep within a period of approximately three weeks. The oral administration of new progesterone compounds may facilitate this type of hormone treatment and result in its wider application. The field trials are being supplemented with laboratory experiments to assess the influence of season, breed and plane of nutrition on reproductive activity. This involves the use of

new bio-assay procedures to assess the influence of experimental treatments on the activity of the endocrine systems of test animals. Work is continuing on the effect of oestrogens and progesterone on the antibacterial activity of the uteri of various species and new work is being started on embryonic mortality in dairy cattle using data made available from the local Milk Marketing Board Artificial Insemination Station.

Microbiological Problems

Work in the Agricultural Botany section on aspects of the pathogenicity of *Rhizoctonia solani* Kühn on the potato continues. Post-planting development of the fungus follows a similar pattern on plants from tubers stored at a range of temperatures. The sequence of disease development is similar on plants grown in wet or dry soil, but differs markedly in degree, being more rapid and severe in dry soils. Stem canker does not occur on plants grown from unscurfed seed.

The possibility of controlling common scab by irrigation has been investigated. Irrigation during the early period of tuberisation (in June), significantly reduces scab; continued irrigation for the remainder of the growing season results in further, but not appreciable, reduction of scab. The effects of these treatments on the ecology of the pathogen are being considered. Studies have also commenced on the effect of green manure on the ecology of *Streptomyces scabies*. Investigations have begun on the role of dew in influencing infection of wheat by *Puccinia graminis f.sp. tritici*, dew formation in crops, and on the the host-parasite relationship of loose smut of wheat (*Ustilago nuda f.sp. tritici*).

Studies on microbial fat have been continued with strains of *Aspergillus ustus* and aspects of the previous work with *Lipomyces* and *Hansenula* spp. published. The potentialities of fresh water algae for assessing soil mineral deficiencies have continued. The study of the Corynebacteriaceae family of bacteria continues and the survey of *Listeria monocytogenes* has been both topical and of value to colleagues overseas.

Studies of sub-lethal heating proceed: those on *Staphylococcus aureus* are being prepared for publication and a satisfactory technique for further work on species of *Microbacterium* has been developed. Studies on soil partial sterilisation continue, changes in the flora are being assessed by a modified nutritional grouping technique and the activity of the organisms' dehydrogenases. The calcium and magnesium needs of diverse *Rhizobium* spp. are being collated. An examination of the flora of milk samples failing the 'clot-on-boiling test' has also been initiated.

Chemical Problems in Food Utilization

Research in the Agricultural Chemistry section is at present directed towards an elucidation of the calcium phosphate-calcium caseinate relationships in milk.

In the Dairy section attention is being given to the development of a quick chemical method of detecting penicillin in milk; studies with the ultra-violet spectrophotometer have been promising. These investigations should also give a clearer understanding of protein-ion binding.

Studies of Invertebrates

The research programme of the Agricultural Zoology Section is concerned principally with investigations of soil-inhabiting arthropods in relation to soil processes, and studies of pyrethrum insecticide from a biological standpoint. Fringe activities include investigations of aphides in relation to the spread of virus disease in potato crops.

The analysis of the results of an investigation of the soil Acarina and Collembola of land restored for agricultural use after opencast ironstone quarrying operations has been completed. Much of this analysis is concerned with the interrelationships of animal species and sampling station, and whether it is possible, on the basis of this information, to select species which characterise the conditions occurring within each station (see page 85). By the use of a multivariate technique of analysis it has been possible to correlate a number of soil factors with a group of animal species, and to consider the effects of these soil factors separately and together in determining the composition of the fauna and *vice versa*. These results point to very interesting possibilities in the use of species as indicators of site characteristics, and it is suggested that although this approach does not appear feasible when using single species, there are indications that groups of species may reflect particular conditions. The results of this study are now being prepared for publication.

One difficulty in the use of soil animals as indicators of site conditions is the apparent ecological plasticity of certain members. A study of two oribatid mites (*Tectocepheus velatus* (Mich.) and *Platynothrus peltifer* (C. L. Koch)) having a widespread distribution has been commenced with the object of determining whether ecological races occur in different habitats, and whether ecotypes, if they do occur, can be identified by external morphological characters.

A study of the fauna associated with the early stages of soil formation in rendzina profiles has been continued. This study is concerned mainly with the Acarina and Collembola components of the fauna, and

some 124 species of mites and 42 springtail species have now been identified. Preliminary results suggest that a fairly rapid build-up in number of species occurs between the moss-cushion and pechrendzina stages, and with a few important exceptions, the process appears to be an additive one. A serious problem in soil-zoological research is the lack of direct evidence of the activities of small animals in the soil. Soil-sectioning techniques are now being used to obtain direct visual evidence of food habits of the Acarina and Collembola. The aim is to use this evidence of animal activity as a means of characterizing biologically the humus forms occurring on the experimental sites.

An important aspect of soil zoology is the role of soil animals in the break-down of organic matter and work is now being directed towards a closer understanding of the food habits of individual species, and the successions of organisms associated with decaying plant material. During the present year a number of microplots of special design have been constructed for this purpose. With the aid of these it is intended to study the sequence of events occurring in the break-down of leaf litter under semi-controlled conditions. A buried-slide technique is also being used to study the successions of animals associated with the decay of simple substrates such as cellulose.

The study of the biology and physiology of individual species of Oribatei inhabiting soil is not easy, partly because of their small size, and partly because of the difficulty of culturing them readily in the laboratory. However, some information can be obtained by investigating the relatively few species that can live outside the soil environment. One of these is *Humerobates rostrolamellatus* Grandjean, a mite which occurs on the bark of apple trees, and may be also found in leaf litter beneath the trees. Sampling populations of old, unsprayed apple trees has indicated that adults of this species retreat from the outer branches and concentrate on the trunk in the late autumn and early winter. Associated with this slow mass movement is a particular increase in clumping of the mites so that by December the adult population is very markedly aggregated, and is confined to a relatively small area. A trapping technique using two polythene water traps per tree has been devised to determine whether there is a movement between the main stem of the tree and the litter layer or *vice versa*. This mite has been fairly readily cultured in the laboratory using an alga (*Pleurococcus* sp.) as a food source, and studies concerned with its life history and the morphological differentiation of the immature stages have been carried out. In addition, a programme of field sampling to obtain information on the bionomics of this species under natural conditions has been almost completed.

The programme of research on insecticides has been concerned mainly with the effects of kind and amount of surfactant and solvent in aqueous-emulsion formulations of pyrethrum, and a considerable number of bio-assay experiments have been carried out using the Potter-tower spray apparatus. The Pea aphis (*Acyrthosiphon pisum* (Harris)) has been the principal species used in these experiments but a number of tests have also been carried out with the following arthropods: adults of the red-spider mite (*Tetranychus telarius* (L.)) and the Mustard beetle (*Phaedon cochleariae* (F.)) and caterpillars of the Large white butterfly (*Pieris brassicae* (L.)). The results of these experiments suggest that an increase in concentration of surfactant (Ethylan BCP) from 0.02 to 0.08 per cent (*W/V*) gives a twenty-fold increase in the potency of the formulation whereas increasing the solvent concentration reduced the potency. With the Pea aphid the addition of a synergist such as sulfoxide or piperonyl butoxide had little effect with formulations having a high concentration of surfactant except at very high concentrations of synergist. The Pea aphis is fairly susceptible to pyrethrum insecticide but the red-spider mite and the Mustard beetle are much more resistant, and further work is being carried out to determine the most suitable formulations for these species.

The fifth and last year of a survey of aphides present in potato crops on the Isle of Man was completed in 1961. There appeared to be no correlation between spread of leaf-roll virus and potato virus Y and the number of aphides in the crop.

Investigations in Agricultural Economics

A survey of commercial egg producers in Nottinghamshire, Derbyshire and Kesteven has been carried out in order to classify commercial egg producers into relatively homogeneous groups by flock size and system of production, to describe the structure and characteristics of the egg producing industry in the East Midlands and to make some estimate of adjustments in progress within the industry. Questionnaires were sent out, early in the year, to 1,044 producers and a preliminary analysis of results has been completed. Work has begun on the collection of financial and physical data on egg production from sub-samples of the producers included in the survey described above. Among the objectives of this study, which will continue throughout 1961-62, are the determination of the cost structure of commercial egg production (variation in cost between producers), capital invested and return on capital, economies effected by adoption of new practices, economies of scale and of intensi-

fication, and relative merits of battery and deep litter systems. Records will be kept by producers continuously over a twelve-month period. The study will also provide data needed for Ministry of Agriculture, Fisheries and Food enterprise costs.

An examination of the agricultural situation in Europe and of the common agricultural policy of the European Economic Community was completed. During the year the following studies have been in progress: (i) A study of factors affecting the adoption of bulk milk collection in Lincolnshire. (ii) A survey of the costs and returns of tomatoes in glasshouses. (iii) A field survey of farmers practising irrigation, priority being given to those intending to irrigate sugar beet and potatoes. (iv) An analysis of the price-acreage response for potatoes, Lincolnshire being contrasted with the remainder of England and Wales. One objective is to determine whether Lincolnshire growers, having a greater capital investment and stake in the crop, are less responsive to short-run price changes than growers elsewhere. (v) A study of the cost of beef fattening on grass. (vi) An enquiry into the economics of maize growing which includes information on the utilisation of the crop by various classes of livestock.

In the Farm Management Survey, financial returns were collected from a total of 248 farms. 61 farmers also co-operated in the investigation into the economics of milk production. Collection of data regarding the costs of the 1960 sugar beet and potato crops has been completed and similar data for the 1961 wheat and barley crops have been collected. The study of the extent and significance of " multiple holdings," i.e. holdings under the management of the same occupier, is still in progress.

Liaison with the National Agricultural Advisory Service has continued and considerable progress has been made in the use of programme planning techniques as a tool in farm management advisory work.

EIGHTH EASTER SCHOOL IN AGRICULTURAL SCIENCE,

April, 1961

PIG AND POULTRY NUTRITION

D. Lewis

The subject of the 8th Easter School in Agricultural Science was "Digestive Physiology and Nutrition of Pigs and Poultry". The proceedings were divided into four main sessions: general physiology and principles of nutrition, environmental physiology, nutrition of poultry and nutrition of pigs.

Professor E. C. Amoroso, F.R.S. (Royal Veterinary College) opened the conference with an account of comparative aspects of reproductive physiology. He also discussed water relationships and chose aquatic animals to exemplify some principles in developmental physiology. Professor F. W. Hill (University of California) followed with an account of the physiology of food intake and digestion in chickens. He described succinctly his work on the determination of the metabolizable energy value of poultry rations, especially those containing added fat. He emphasised the importance of 'energy' in regulating food intake. A general account of the physiology of growth was given by Sir John Hammond, F.R.S. (Cambridge) who pinpointed clearly the particular relationship of growth and development to plane of nutrition.

The first section was completed by papers from Dr. K. J. Carpenter (University of Cambridge) and Dr. D. Lewis (University of Nottingham) who dealt with the evaluation of dietary energy and protein metabolism and nutrition respectively. Carpenter considered the development of concepts of evaluating the 'energy' of feeds and critically compared the productive energy and metabolizable energy approaches. Lewis emphasised that improvements in protein nutrition are possible by eliminating empirical dietary excesses and margins of safety by using present knowledge of the roles of dietary constituents in metabolism. Mr. D. G. A. Guttridge (University of Nottingham) reviewed methods of assessing dietary amino acid availability and described a bio-assay of methionine and cystine using the young chick.

The second main session was opened by Dr. L. E. Mount (A.R.C. Institute of Animal Physiology) with an account of developmental aspects of the environmental physiology of the pig. He reviewed knowledge on the relationship between metabolic rate and body temperature in the new-born pig. The influence of the climatic environment upon pig and poultry performance was discussed by Dr. P. H. Sørenson (Royal Veterinary and Agricultural College, Copenhagen) and Dr. C. G. Payne (University of Nottingham) respectively. Sørenson particularly described the effects of ambient temperature on live weight gain and commented upon thyroid inter-relationships. In addition to describing the effects of temperature Payne emphasised the importance of lighting control in the production of poultry.

A masterly evaluation of dietary factors in broiler production was given by Professor G. F. Combs (University of Maryland). His work on the inter-relationship of dietary energy and protein gave much of the impetus that has led to the recent efficiency of production of poultry meat. Dr. T. G. Taylor (University of Reading) described calcium absorption and metabolism in the laying hen and Dr. M. E. Coates (National Institute for Research in Dairying) commented on the relationship between alimentary microflora and nutrition in poultry. Dr. W. Bolton (A.R.C. Poultry Research Centre, Edinburgh) integrated concepts of nutrition into practical details of the formulation of poultry diets.

The final section dealt with the main subject of pig nutrition. The individual speakers considered the several phases in the development of the pig starting with an account by Dr. J. Moustgaard (Royal Veterinary and Agricultural College, Copenhagen) of foetal nutrition. In assessing dietary requirements he pointed out the necessity to distinguish between the needs of the products of conception and needs outside the reproductive organs. The related subject of the nutrition of the pregnant sow was dealt with by Drs. E. Salmon-Legagneur and A. Rerat (Centre Nationale de Recherches Zootechniques, Jouy-en-Josas). The contributions of Drs. G. A. Lodge and I. A. M. Lucas (Rowett Research Institute) dealt with the nutrition of the lactating sow and the young pig respectively. Lodge pointed out the difficulties of evaluating dietary requirements from first principles and emphasised the almost complete lack of precise information on the optimal nutrition of the sow during lactation. Lucas dealt particularly with colostrum, digestive enzymes, energy requirements and creep feed.

The nutrition of pigs from weaning to slaughter was reviewed by Dr. J. T. Morgan and Mr. D. W. Robinson (University of Nottingham). They also described their work on energy—protein balance in pig rations and on the optimum time of change from a 'starter' to a 'finisher' ration. Drs. R. Fuller (National Institute for Research in Dairying) and C. A. E. Briggs (Pfizer Limited) discussed the bacteriology of the alimentary tract of the pig. Dr. R. Braude (National Institute for Research in Dairying) focussed attention upon some management and production problems in the pig industry. He also re-emphasised his contention that the fat content of the pig carcass must be strictly regulated. The proceedings closed with an admirable account by Professor E. W. Crampton (McGill University, Canada) of technical and economic considerations in ration formulation.

The Eighth Easter School in Agricultural Science demonstrated that improvements in performance standards coupled with intensive methods of production in the pig and poultry industries serve to focus attention upon the need for precise knowledge regarding nutrient requirements for growth and reproduction. Precision is in fact probably the keynote of present and future developments in the nutrition of farm animals. In common with all other classes of livestock the pig and the domestic chicken require for optimum growth and efficiency of food utilization that their rations contain a certain specific quantity and balance of each dietary constituent. Advances in the efficiency of livestock production are now rigidly dependent upon the precision with which these optimal dietary requirements can be defined.

The Proceedings were published in January, 1962, by Butterworths Scientific Publications, London, under the title "Nutrition of Pigs and Poultry."

SPROUT GROWTH OF THE POTATO

D. W. R. Headford and E. M. Ingersent

In recent years considerable interest has been shown in ways of manipulating the growth of sprouts on potato seed tubers in order to obtain earlier and higher yields from the resulting plants. The number and size of sprouts at planting, which influence the course of subsequent growth, are the result of a series of previous events which can perhaps be best traced by following the history of an individual tuber from its inception.

At the time of tuber initiation, the first elongating internode behind the terminal "bud" commences to swell. At this time in the terminal "bud" of the stolon there are about 12 axilliary buds, the oldest of which has differentiated 3-4 leaf primordia. As the tuber grows the internodes expand, more leaf primordia and buds are differentiated by the terminal meristem, and the buds on the expanding tuber continue to differentiate until 9-10 leaf primordia are formed. The mature tuber therefore consists of the basal "eye", 10-12 lateral "eyes" or buds and the apical bud, which also has 9-10 leaf primordia but which is larger than all other buds. At this time growth of all buds has ceased or is very slow.

The nature of dormancy in buds on the potato tuber is still far from clear. There seems little doubt that the lateral buds have a similar behaviour to those on other stems and enter a quiescent or dormant state soon after they are differentiated. The apical bud, however, contains the persistent apical meristem of the stolon; it is active during the growth of the tuber and may never be fully dormant. If conditions during tuber expansion are dry, the apical bud often resumes growth as a stolon; i.e. the basal internodes of the apical bud expand longitudinally rather than radially. Growth of the apical bud of some varieties and under some conditions may continue after lifting without cessation; elongation of sprouts after lifting often follows an exponential course with time and the "apparent dormancy" may well reflect the time required for the sprout to grow to the stage where it is visible to the naked eye.

At some period following lifting, sprout growth is visible and continues until planting. The number and size of sprouts formed during this period can be greatly modified by the temperature, humidity, and light conditions during storage, the times of exposure to these conditions, and by size of the parent tuber; the degree of response varies greatly

with variety. Apical sprouts grow at first fastest at 25°C but the initial growth rate is not maintained throughout the whole storage period (Fig. 1). Consequently, the temperature producing the largest sprouts depends on the length of storage, the largest sprouts being eventually produced at 15°C (59°F). Growth at 30°C (80°F) is at first similar to that at 10°C (50°F) but after a time the growing point dies and multiple branches are produced. Sprouts on tubers stored at 25° and 20° behave similarly but a longer time elapses and a greater sprout length is achieved before the apex dies. The variety King Edward behaves similarly to Arran Pilot although the rate of sprout elongation is less at all temperatures. Rapid elongation of the apical sprouts on tubers stored on lifting between 15° and 25°C results in suppression of the other buds, so that only one or sometimes two large sprouts are produced. If, however, tubers are stored at 2-5°C all sprouts grow very slowly and if later the tubers are transferred to higher temperatures several large sprouts are produced.

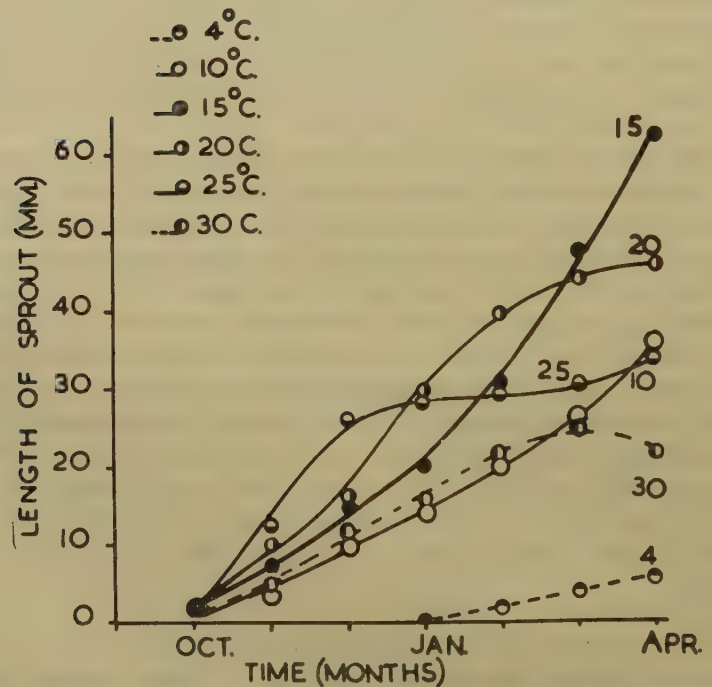

Fig. 1. The growth of the apical sprout on tubers of Arran Pilot stored at different temperatures after lifting.

This phenomenon of apical dominance is little understood and is the subject of further investigations. It may be associated with the larger size and the better-developed vascular system of the apical bud at lifting.

The presence or absence of light has a considerable effect on the nature of the sprout, sprouts developing in complete darkness being long and etiolated. Tubers lifted in July and August and placed in trays stacked in the field for 4-8 weeks results in early and dominant growth of the apical sprout. This practice is followed by growers of "early" potatoes from home-grown seed. It seems possible that light may be concerned in this early growth of the apical sprout, which is much greater than from tubers left in the soil for the same length of time. (The soil and air temperatures are similar during this period). An experiment in which King Edward tubers were exposed to different intensities and lengths of photoperiod from December to April showed that there was only a small effect of the amount of light per day and the manner in which it was given over the range 1-29 cal./cm.^{2}/day. Sprouts were slightly longer with low rather than high radiation but the numbers growing were not influenced. The lowest intesity used in this experiment was about equivalent to the highest normally found in an artificially-illuminated commercial store. Although further investigations are required with lower amounts of light than used in the above experiment, it seems likely that light does not have nearly as large an effect as temperature provided tubers are exposed to some light for a few hours each day.

Growth of the sprouts during storage is very closely related to the amount of substrate available, i.e. to the size of tuber or tuber piece available to each sprout. For example, the weights of sprouts after 14 weeks of growth at 20°C from single-sprout tuber pieces of 1, 4, 16 and 64 g. were 5.5, 21, 112 and 407 mg. respectively. The dormancy of all buds on tubers of 80 g. weight was broken with ethylene chlorhydrin and buds removed to leave 1, 2 or 4 per tuber. After 14 weeks the total sprout weight produced was similar in all, the weight of the sprout on the single-sprout tuber being about four times the weight of an individual sprout on the four-sprout tuber. Further, tuber pieces of 20 g. with one bud, 40 g. with two buds and 80 g. with four buds were taken. The mean weight per sprout after 14 weeks was similar in all treatments. It is likely that the supply of either nitrogen or phosphorus or both may be limiting the growth of sprouts in storage. The concentration of nitrogen in the sprouts with one and with four sprouts per tuber after 12 weeks growth was 3.3 and 2.9% respectively, although the total nitrogen content of the tuber (1.24% dry weight) was reduced by only 6-10% during this

period. Carbohydrate supply is not likely to be involved as a large supply is potentially available, a proportionately smaller supply is available from small than large tuber pieces (due to respiration losses), and small tuber pieces have a higher concentration of soluble sugars than large pieces. Water supply is one factor definitely concerned, as with the development of roots and water uptake on sprouts stored at very high humidities or planted in moist soil (see Fig. 3) the rate of sprout growth increases rapidly.

The number and size of sprouts on tubers at planting can therefore be controlled by manipulation of the storage conditions. If many very small sprouts are required at planting, these can be obtained either by storage at very low temperatures (2-5°C) or by removal prior to planting of the longer sprouts produced at higher temperatures. A number of large sprouts can be produced by first storing at low temperatures for a few months and then transferring to temperatures of 10°-25°C for 2-3 months before planting. If the apical bud is removed at the time of transference more even growth of the resulting sprouts will be obtained. If only one or two large sprouts are required at planting the tubers should be stored on lifting at high temperatures and exposed to light and later transferred to low temperatures to retard excessive elongation of the sprout. The actual sizes and numbers of sprouts produced under any given set of conditions varies with variety and with size of the present tuber. For example, varieties such as Arran Pilot produce rapidly elongating sprouts whereas sprouts of King Edward and Majestic grow more slowly. Large tubers produce more and faster-growing sprouts than do small tubers.

The size and number of sprouts on tubers at planting considerably influence the subsequent growth of the plant. The main result of large sprouts at planting is to obtain earlier emergence of plants and earlier initiation of tubers (Fig. 2). There is, however, a limit to the length of sprout beyond which no further advantage is obtained. Data obtained from Arran Pilot and King Edward (Fig 2) suggest that there is no advantage in producing sprouts greater than about 2 cm. (say, $\frac{3}{4}$-1 inch). Some indirect evidence suggests that sprouts produced soon after lifting and then retarded by low temperature do give earlier tuber initiation than sprouts of the same length produced fast before planting. Such, if true, could be associated with greater differentiation of stolons but no unequivocal information is available; a detailed investigation of the technique of "greening" used by growers of "early" potatoes is required.

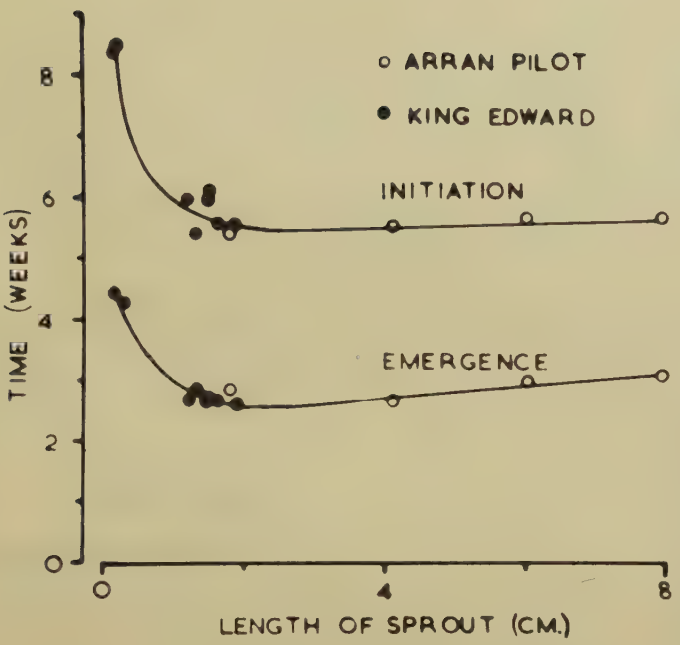

Fig. 2. The relation between times to emergence and to tuber initiation and length of sprouts at planting of tubers of King Edward and Arran Pilot grown in the field.

Although the production of large sprouts before planting shortens the time between planting and tuber initiation, the growth rate of the resulting plants is considerably reduced. This is illustrated by an experiment in which tubers stored under constant conditions were planted and grown at different times in a constant environment (Fig. 3). Although the relative growth rate increased greatly on planting, it was lower the larger the sprout at planting. This reflects the inability of the plant to develop and maintain a large leaf surface, especially after tuber initiation. If a large haulm is developed before tubers are initiated the new tubers have a long period of bulking before senescence and high yields are obtained. If a small haulm only develops by the time of tuber initiation, then the growing tubers retard the growth of new leaves, the plant matures and senesces more quickly and lower final yields result.

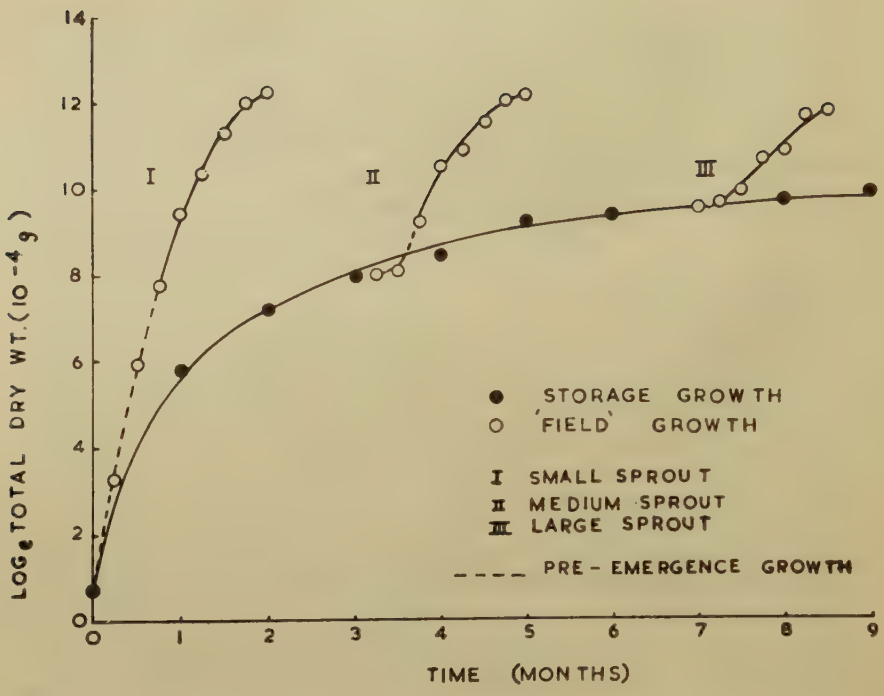

Fig. 3. The relationship between the logarithm of sprout or plant weight and time for tubers stored at 20°C (black circles) and following planting at 3 different sizes (white circles). The "field" growth was that made in pots in a plant-growth room at 20°C and illuminated with 80 cal./cm.^{2}/day fluorescent light over a 16-hour day. Note the differences in the shapes of curves I, II, and III.

The number and size of sprouts required at planting depends then on the object for which the crop is grown. If grown for very early production, then a large tuber with few large sprouts at planting is the ideal. These give early emergence with early tuber initiation and hence a commercial yield early in the season. However, such plants mature early and the maximum possible yield is low. With an unlimited growing season, highest yields at maturity would be obtained from planting tubers with extremely small sprouts. Although emergence and tuber initiation is delayed, senescence of the haulm is also slow and a long period is available for bulking. However, in Britain, the growing season is often limited by blight or autumn frosts and usually the advantages of earlier emergence and tuber initiation gained by planting "sprouted" seed, even of maincrop varieties, outweigh the possible gains arising from a long period of natural bulking.

SEED SIZE AND SPACING IN THE POTATO CROP

P. M. Bremner, M. A. Taha and A. K. El Saeed

Table I summarises the treatments in and results of the seed size and spacing experiments carried out with the potato crop at Sutton Bonington during the last three years. In 1959 and 1960 experiments were identical in design, but in 1961 the treatments were rearranged in such a way as to enable a more direct estimation of the effects of *seed rate*.

TABLE I

EFFECTS OF VARIETY, SEED SIZE AND SPACING ON WARE AND TOTAL YIELD.

Year	Variety	Seed wt. (ozs.)	Spacing (inches)	Corresponding seed rate (cwt. per acre)	Total Yield T/ac.	Ware Yield (over 1¼") T/ac.
1959	Majestic	1.37	12	14.2	12.53	10.37
			18	9.5	12.27	10.70
			24	7.1	11.46	10.27
		3.30	12	34.3	12.62	9.25
			18	22.9	12.35	10.24
			24	17.2	11.68	10.06
	King Edward	1.06	12	11.3	12.00	6.41
			18	7.5	11.58	7.57
			24	5.6	9.95	6.85
		2.89	12	30.1	12.39	6.03
			18	20.1	12.49	7.06
			24	15.0	11.52	7.51
				S.E.	±0.460	±0.436
1960	Majestic	1.31	12	13.6	17.17	16.44
			18	9.1	16.63	16.19
			24	6.8	16.38	15.96
		3.50	12	36.4	18.77	17.78
			18	24.3	17.74	17.13
			24	18.2	16.49	16.02
	King Edward	1.19	12	12.4	14.49	12.92
			18	8.3	14.08	12.60
			24	6.2	13.37	12.56
		2.89	12	31.2	16.04	13.74
			18	20.8	15.35	13.71
			24	15.6	14.44	13.11
				S.E.	±0.543	±0.499
1961	Majestic	1	9	13.9	20.04	15.99
			12	10.4	20.71	17.76
		2	9	27.8	20.66	16.14
			12	20.8	19.90	16.59
			18	13.9	19.25	16.42
			24	10.4	19.19	16.69
		4	18	27 8	19.23	15.98
			24	20.8	19.03	16.08
				S.E.	±0.836	±0.735

Climatic peculiarities of the seasons concerned had, as will be seen, a profound influence on the results, and indeed the series (as yet incomplete) provides a salutary lesson on the need to run the conventional

type of field trial for at least three years. The first season was one of extreme drought; the second one of early blight attack; and in 1961 occurred the most severe late frost recorded for many years.

Noteworthy with regard to varietal performance is the marked superiority of Majestic in total yield in 1960, and in ware yield in both years (Table II).

TABLE II

MAIN EFFECT OF VARIETY ON TOTAL AND WARE YIELDS

	1959		1960	
	Total	Ware	Total	Ware
Majestic	12.15	10.15	17.20	16.59
King Edward	11.66	6.91	14.63	13.11
S.E.	±0.188	±0.178	±0.222	±0.204

Difference in duration of tuber bulking, rather than in bulking rates, was responsible for the total yield effects (cf. [1]): Majestic was, in both years, slightly earlier to initiate tubers (this was its sole advantage in 1959), and in 1960 it also benefited from foliage persistence for 7-10 days after that of King Edward had been killed off by blight. A lower proportion of the total produce was in the ware grade in King Edward, especially in 1959, and this was doubtless related to the tendency of this variety to produce greater stem and tuber numbers than did Majestic—tuber numbers being in fact some 40% greater. Inter-tuber competition would thus be greater in King Edward, with consequent restriction in individual tuber size. The economic consequences of this difference between the varieties were considerable in 1959, when inter-plant competition for water was most intense, and only some 60% of the total yield of King Edward fell into the ware category, as compared with over 80% in Majestic.

In 1959 and 1960 large seed outyielded small seed, this being in line with the results of other investigations, but in 1961 there was no difference (Table III).

TABLE III

MAIN EFFECT OF SEED SIZE ON TOTAL AND WARE YIELDS

	1959		1960		1961	
	Total	Ware	Total	Ware	Total	Ware
Large seed	12.17	8.36	16.47	15.25	19.71	16.20
Small seed	11.64	8.70	15.36	14.45	19.80	16.69
S.E.	±0.188	±0.178	±0.222	±0.204	±0.418	±0.368

First, regarding the lack of difference in 1961, it should be noted that the difference in size between " large " and " small " seed was less in this year than in the other two; probably more important than this,

however, was the effect of the late frost, which was observed to be more damaging to the more forward plants from large seed, in nullifying normal seed size effects. The differences which occurred in 1959 and 1960 were due to differences in duration, rather than rate of bulking, and the differences in duration were brought about mainly by tuber initiation some 4 - 5 days earlier in large seed. This earlier tuber initiation was sufficient, at the bulking rates pertaining in the two seasons, to establish and maintain a total yield advantage for large seed of $\frac{1}{2}$ ton per acre and just over 1 ton per acre in 1959 and 1960 respectively. Thus, the superiority of large seed in the potato crop would appear to lie in more vigorous sprouting and earlier emergence with related earlier tuber initiation, subsequent bulking rate being no greater than that of small seed, though the relative growth rate of plants from small seed is greater than that of plants from large seed, because of the earlier onset of inter-plant competition in the latter. In all years a greater proportion of the produce from small seed fell into the ware category, and, as in the case of varieties, this effect may be the result of different levels of inter-tuber competition consequent upon different tuber numbers in the two seed sizes. In 1959 and 1961, this resulted in higher yields from small seed, but in 1960 the greater total yield from large seed was sufficient to ensure greater ware yields too.

Total yield per plant decreased and yield per unit area increased as spacing distance decreased, though this effect was less marked in 1960 than in the other years. Differences in bulking rates were mainly responsible, there being little difference between the spacing treatments as regards time of tuber initiation or in persistence of foliage. The proportion of the total produce falling into the ware grade increased as spacing distance increased, and this effect is perhaps best considered in the light of tuber numbers per unit area: though tuber numbers per plant increased as spacing distance increased, the closely-spaced plants had a considerable advantage in tuber numbers per unit area, leading to more intense inter-tuber competition and restriction of tuber size.

Much interest has been aroused by the claim of Boyd and Lessells[2] that "provided the optimum seed rate is attained, the precise combination of seed size and spacing distance appears to be of minor importance . . . ." This implies that, within fairly wide limits, the differences in yield (total or ware) between various seed size and spacing combinations of the same seed rate are practically negligible, and indeed their composite curves for a great number of experiments indicate that this is substantially the case within range of seed rates normally employed for ware production, though at lower seed rates small seed are superior, and at higher seed rates large seed are superior. Holliday[3] considers

this superiority of small seed at low and moderate seed rates to be due to more even shoot distribution.

Data from the present series suggest that, within the range of seed rates normally used for ware production, small seed have a greater advantage over large seed at the same seed rate than Boyd and Lessells supposed: this would appear to be the case in 1959 and 1960, though the data are limited in so far as there is no overlap of seed rates between large and small seed; it is certainly true of the 1961 experiment, where overlap was complete, and where small seed outyielded large seed at the same rate by $\frac{3}{4}$ - $1\frac{1}{2}$ tons per acre, though it should be remembered that this was a year in which the normal seed size effects did not obtain. Herein lies the weakness of seed rate as a means of expressing plant population: the effect of seed size on yield, and with it the degree of independence of seed rate of seed size, varies considerably from year to year. The relationship between seed rate and ware yields was, over the three years as a whole, much more erratic than Boyd and Lessells suggest: there was a general tendency for these to decline with increasing seed rate in 1959, to increase with seed rate in 1960, whilst in 1961 they appeared to be largely independent of seed rate.

The present series confirms the suggestion of Reestman and de Wit[4] that shoot number per unit area is a better basis for expression of plant population than seed weight per unit area, being largely, though not wholly, independent of seed size. Within the limits of the overlap of the curves from small seed and large seed, large seed outyielded small seed at the same shoot population per unit area; this is doubtless a result of the greater vigour, earlier emergence and earlier tuber initiation of large seed, which was apparently more than sufficient to offset any possible effects of the more even shoot distribution in small seed.

Finally, a programme concerning the effects on total and ware yields of irregularity in seed size and spacing and a combination of the two has been initiated. The first experiment in this series was carried out in 1961, and the results indicated that irregularity in spacing could reduce yields, though irregularity in seed size had no effect—as might be expected in a season in which seed size effects were nullified by freak climatic conditions.

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GENETIC ANALYSIS OF GROWTH IN TOMATO

W. J. Whittington and A. I. Kheiralla

Terms basic to Genetics such as dominance and epistasis (gene interaction) developed from the study of discontinuous variation between individuals but, like the concepts they describe, they have also passed into use in the study of continuous variation. Unfortunately these terms describe the relationship between parents and hybrids at one moment of time only. Both branches of genetics, therefore, suffer from the same fixation—they neglect variation between parents and hybrids with time.

New methods of analysis in genetics such as the diallel[1,2] in which in the F_1 generation any number of parents and all the possible hybrids are studied, have concerned themselves with such characters as time to flowering and final grain yield of cereals. The results are expressed in genetic terms of additivity, dominance, epistasis or over-dominance and no interest is displayed or genetic description made of the way the plants developed to flowering or maturity. Perhaps this does not matter for the two states mentioned are only represented by single points in time. On the other hand, the farmer may utilise some crops at varying stages of maturity or take successive harvests. The breeder must, therefore, attempt a genetic analysis over the entire period of growth if he wishes to improve his chance of producing superior products. Is it likely then that the genetic control of, for example, yield of forage remains constant with time? If not how can such variation with time be accounted for and described in a genetic experiment. There is evidently need to combine genetic and physiologic studies and this was attempted in the experiment to be described.[3]

The experiment, in which five tomato varieties and all possible crosses between them were studied, was carried out in a glasshouse during the summer of 1960. The varieties were Red Currant (*Lycopersicon pimpinellifolium*) and Amateur, Potentate, Radio and Outdoor Wonder (*L. esculentum*). Two treatments, namely the removal and retention of side-shoots were included in the randomised block design. Three replicates of the treatments, one from each block, were harvested at each of six fortnightly periods and the total dry weight, leaf area, fruit number and fruit weight per plant were determined.

The results of analyses of variance on both log dry weight and leaf area data were similar in showing significant effects of varieties, the linear and quadratic components of time and their interactions. The removal of side-shoots reduced both leaf area and dry weight per plant but the effect was least apparent on Potentate and Radio which had been bred for greenhouse production where this treatment is standard practice.

For dry weight, heterosis was shown by inter-specific crosses rather than intra-specific crosses and maternal effects of variation in seed size between *L. pimpinellifolium* and *L. esculentum* were also apparent in both leaf area and dry weight data.

Estimates of relative growth rates from changes in dry weight (w) with time were obtained by fitting orthogonal polynomials.[4]

$$\log w = a + b_1\xi_1' + b_2\xi_2' + \ldots\ldots \quad (1)$$

where ξ_1' and ξ_2' are orthogonal polynomials in time and b_1 and b_2 provide independent estimates of slope and curvature. Where side-shoots were retained Potentate and Radio had the lowest relative growth rate while Red Currant had the highest; the growth rate of the latter, however, was markedly reduced by the removal of side-shoots. Consistent differences in linear regression values were found between the reciprocal inter-specific but not the intra-specific hybrids. Although initially smaller than its reciprocal the faster growing hybrid from the inter-specific crosses was always derived from Red Currant as maternal parent and thus at the end of the experiment the reciprocal hybrids had reached a similar size.

The net assimilation rates under both treatments increased initially and then decreased prior to a final rise. Although the initial rise clearly followed from an increase in total daily radiation the final rise can only be explained by variation in the proportion of young, mature and senescing leaves or in the rate of fruit development. It seems unlikely that net assimilation rate can prove of real value as a genetic parameter for use in plant improvement because it varies so greatly with the stage of development of the plant. This conclusion applies more, perhaps, to species such as tomato and potato where the production of fruit and tubers continues over a long period than to cereals where the pattern of development is simpler.

The short duration of the experiment made it difficult to study the development of fruit with time but the data from the final harvest allowed comparisons of yield. Red Currant had the lowest and Amateur had the highest dry weight yield where side-shoots were retained but again these varieties were more affected than Radio and Potentate when side-shoots were removed. Heterosis for fruit yield was present under both treatments and tended to involve inter-specific crosses where side-shoots were retained and intra-specific crosses where they were removed.

The simplest method of obtaining information from the diallel cross is to plot the covariance against the variance of an array where the array consists of one parent and all its crosses.[5] The regression line fitted to

the points of the arrays lies within a limiting parabola and its slope and position indicates various degrees of dominance, additivity and gene interaction. The position of the array points on the regression line gives an indication of the relative frequency of dominant or recessive alleles in any parent.

The interpretation of the graphs for $\log_{10}$ fruit number at final harvest showed additive gene action with incomplete dominance while Red Currant had most dominant alleles since, irrespective of treatment its position on the regression line was closer to the origin. Where analyses on dry weight or leaf area data for successive harvests were made the results were not constant with time. For dry weight of entire plants incomplete dominance gave way to overdominance while for leaf area the points appropriate to the Red Currant and Radio arrays showed complete inversion with time. Similarly the removal of side-shoots led to apparent gene interaction.

This variation with time followed from the fact that the relationships between parents and hybrids were constantly altering since they differed in growth rate. In particular the onset of fruiting had a pronounced effect on the rate of fall in growth rate and entirely altered the genetic answers obtained after this time from those that applied before flowering.

The variation in genetic answers with time was avoided by applying the analysis to estimates of growth rates. These were obtained by converting Equation (1) to the quadratic in time and differentiating; this gives:—

$$\frac{1}{W} \cdot \frac{dw}{dt} = b + 2ct \quad \ldots\ldots\ldots \quad (2)$$

where b is the initial relative growth rate and 2c the rate of change with time (t). With all varieties 2c was negative, showing a decrease in relative growth rate with time. High initial rates of growth were always associated with high rates of fall.

The parameters above were then used in the diallel analysis and yielded evidence of heterosis for initial growth rate of entire plants. Overdominance was present for the initial growth rate but not for the rate of change with time.

The combination of growth analysis and genetic techniques as well as explaining apparent variation in genetic control of growth with time also led to interesting findings about the development of heterosis. In particular it emphasized how important the relationship between the roots, shoots and fruit of the plant is in dictating what pattern of growth

emerges. These organs represent both the " sources " of nutrient and " sinks " for their utilization and variation between parents and hybrids in the development of any one organ have far reaching consequences. It is likely that the heterosis observed at the seedling stage was dependent upon interaction of this sort rather than vague assertions about the greater biochemical versatility of hybrids. [6]

The results of the experiment described above makes more obvious the extent to which the geneticist, by ignoring variation in development with time, may be in danger of misleading others about the meaning of words such as dominance and interaction adopted from studies on " major gene " effects. No difficulty ensues provided that it is understood that these relate only to the average of all gene effects expressed up to the moment of harvest. Indeed, the knowledge of genetic systems from the diallel may be exact enough to enable the plant breeder to direct his breeding operations more skilfully. Unfortunately the restrictions imposed by geneticists in their analyses have tended to encourage the view that separate gene systems control the growth of different plant organs while the reality that their development is part of a general growth process is clearer to a physiologist. In this sense, therefore, simultaneous consideration of both the physiology and genetic control of rates of development in plants may serve a useful purpose. This represents a return to the work initiated by Ashby[7] but subsequently neglected, probably as a result of the absence of suitable methods of genetic analysis. The methods described above are now being used on later segregating generations derived from the above material in the hope that this will yield more information about the genetic control of development.

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THE METABOLISM OF PLANTS AFFECTED BY IRON DEFICIENCY

G. Norton

Chlorosis is a general term used to describe plant tissues which are lacking in chlorophyll and can be caused by a number of metabolic disorders often related to the deficiency of a particular element. Where it is iron that is deficient the condition is referred to specifically as iron chlorosis.

A simple deficiency of iron is rarely found in the field but iron chlorosis can be induced by a variety of soil conditions. An excess of lime, for example, will bring about a deficiency of iron, commonly termed lime induced chlorosis, while an excess of heavy metals such as nickel copper, cobalt, chromium and manganese result in metal induced chlorosis.

Plants differ in their susceptibility to iron deficiency. Calcifuge species such as lupin (*L. luteus*) azaleas, etc. are extremely sensitive to lime induced chlorosis, while calcicole plants, as for example, sainfoin and lucerne are tolerant to high lime. It is obviously of some importance to determine the biochemical basis for these differences.

One method of investigation would be to study enzymes or enzyme systems isolated from normal and iron deficient material. Alternatively, an indirect approach could be employed by studying the accumulation or depletion of metabolites in the normal and iron deficient material and from this to deduce the sites of action of iron. The second approach was the one adopted here since the activity of enzymes *in vitro* may bear little resemblance to their activity *in vivo*.

A characteristic and well known feature of iron and other trace and major element deficiencies (excluding molybdenum) is an accumulation of soluble nitrogenous compounds in the affected parts of the plant. Experiments elsewhere with tomato have shown that each mineral deficiency produces a different effect on the pattern of the soluble nitrogenous components. It would then appear reasonable to assume that the amino acid and amide pattern of iron deficient lupin was specific to the deficiency and species. The amides, glutamine and asparagine appear to be directly affected by iron deficiency [1, 2, 3] when up to 10-fold increases in either one or both of these compounds have been recorded (Table 1). In the lupin aspartic acid, γ-amino-butyric acid alanine, serine and leucine in addition to asparagine are affected more than phenylalanine, glutamic acid, glycine, threonine, proline, valine and arginine.

TABLE 1

THE EFFECT OF IRON DEFICIENCY ON THE CONCENTRATION OF AMINO ACIDS IN LUPIN SHOOTS. Mgm./gram DRY WEIGHT.

	Normal	Iron deficient
Alanine	0.14	0.83
γ-amino-butyric	0.34	0.93
Asparagine	0.44	2.95
Aspartic acid	0.21	0.81
Glutamic acid	0.06	0.12
Glycine	0.11	0.21
Leucine	0.065	0.21
Serine	0.14	0.42

It is plain that iron has no specific effect on the metabolism of an individual amino acid or a related group of amino acids and in consequence the interpretation of the results from such analyses is rather difficult. Iron has a marked effect on the nitrogen metabolism of the plant but whether these observed effects are a direct or indirect result of the deficiency cannot be distinguished by simple analyses of this type. The metabolism of amino acids and carboxylic acids are closely connected but an examination of the carboxylic acids of iron deficient tissue showed only an increase in citric, malic and succinic acids[2].

These preliminary investigations indicate that the relationship between iron and the intermediary metabolism of the plant is complex. Gross organic analysis of plants or tissues affected by iron deficiency could only, at the most, be expected to yield leads into the problem. Bearing this in mind certain aspects of this work are worthy of further consideration. Large accumulations of aspargine and/or glutamine are associated with accentuated protein degradation. The amino acids resulting from this breakdown are selectively used to maintain respiration, arginine and asparagine being the ultimate products of these processes. The increase of amides and certain amino acids in iron deficient tomato has been assumed to be a result of protein degradation[1]. Although this increase in amides in lupins could be due to an enhanced proteolysis the accumulation of at least one amino acid, e.g. γ-amino-butyric acid, could not be explained on that basis since it has not been shown to be a constituent of plant protein. Amides have also been found to accumulate in lupin in the early stages of iron deficiency where chlorosis was just visible before growth was affected. Under these circumstances a decreased protein synthesis, rather than an accentuated protein degradation, might be operative.

Protein synthesis is an endergonic process utilizing the energy released during the oxidation of carbohydrates. In iron deficient plants the respiratory and photosynthetic mechanisms are probably impaired. Respiratory mechanisms could be affected directly by iron deficiency bringing about a decrease in activity of an iron containing enzyme involved in intermediary metabolism, a suggestion supported by the accumulation of citric, malic and succinic acids in deficient tissues. Chlorosis would reduce photosynthesis which in turn would decrease the amounts of carbohydrate available for respiration. A decrease in respiration and photosynthesis would reduce the amount of energy available for synthetic purposes, e.g. protein and cell wall synthesis.

Certain other factors must be borne in mind when considering the data from experiments of the above type. First, the inability to distinguish by simple analysis primary and secondary effects of iron deficiency. Secondly, total analyses of the above type do not take into account the existence in plants of pools of metabolites some of which may be active and some inactive.

The work discussed so far has been carried out using material exhibiting symptoms of iron chlorosis and in which primary effects were probably swamped by many secondary effects. The most important aspect of this problem now is to elucidate the primary effect of iron deficiency on the metabolism—an effect which could occur before chlorosis is visible.

The problem is being studied in several stages; (a) respiration and respiratory pathways in the absence of photosynthesis, (b) photosynthesis and (c) enzyme studies following deductions from (a) and (b).

Preliminary experiments have been designed in which lupins were grown in water culture under controlled environmental conditions, and it was found that after transferring seedling plants (2nd leaf stage) to solutions with no added iron, deficiency symptoms were just visible on the 3rd leaf after five days. In all the experiments described below this 3rd leaf in an early stage of iron deficiency has been used in the hope that only primary metabolic upsets will be present. The picture was simplified further by supplying glucose as respiratory substrate.

The initial respiratory experiments have revealed some interesting and unexpected results (see Fig. 1). Oxygen uptake studies indicate that under the conditions used oxygen was more rapidly utilized by iron deficient material. Consistent results show that the increase in respiratory rate was of the order of 30%. A more detailed examination of the nature of this increase is now being undertaken, using radio-active

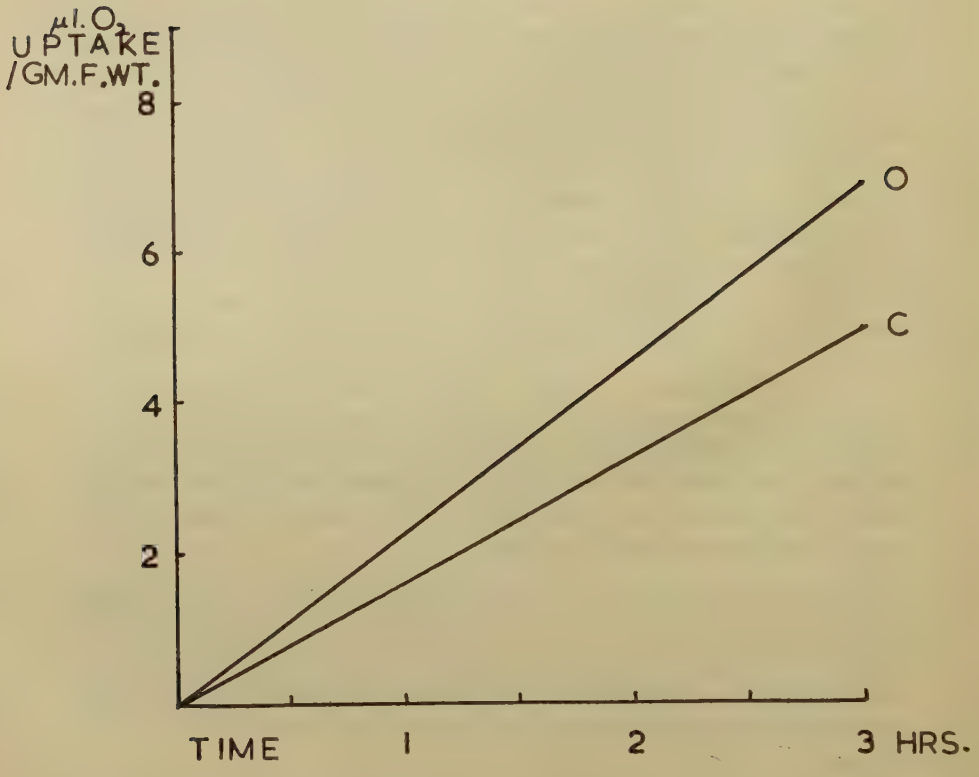

Fig. 1. Respiration of lupin leaves.

O — no iron supplied.
C — normal iron.

tracers which should also enable metabolically active and inactive pools to be distinguished. Experiments were carried out using the same system as before but with the incubation medium consisting of glucose labelled with ^{14}C and a facility for sampling the respiratory $^{14}CO_2$ every 10 minutes. This enabled the rate of evolution of $^{14}CO_2$ to be followed throughout the experiment. A final assessment of the total radio-active carbon taken up was obtained by extracting the tissues with 80 and 20% ethanol. The results obtained for $^{14}CO_2$ release are presented in Fig. 2. The $^{14}CO_2$ evolution pattern was similar to that of oxygen uptake indicating that the externally supplied glucose was the respiratory substrate. Again respiratory rate increases of iron deficient material were of the order of 25-30%.

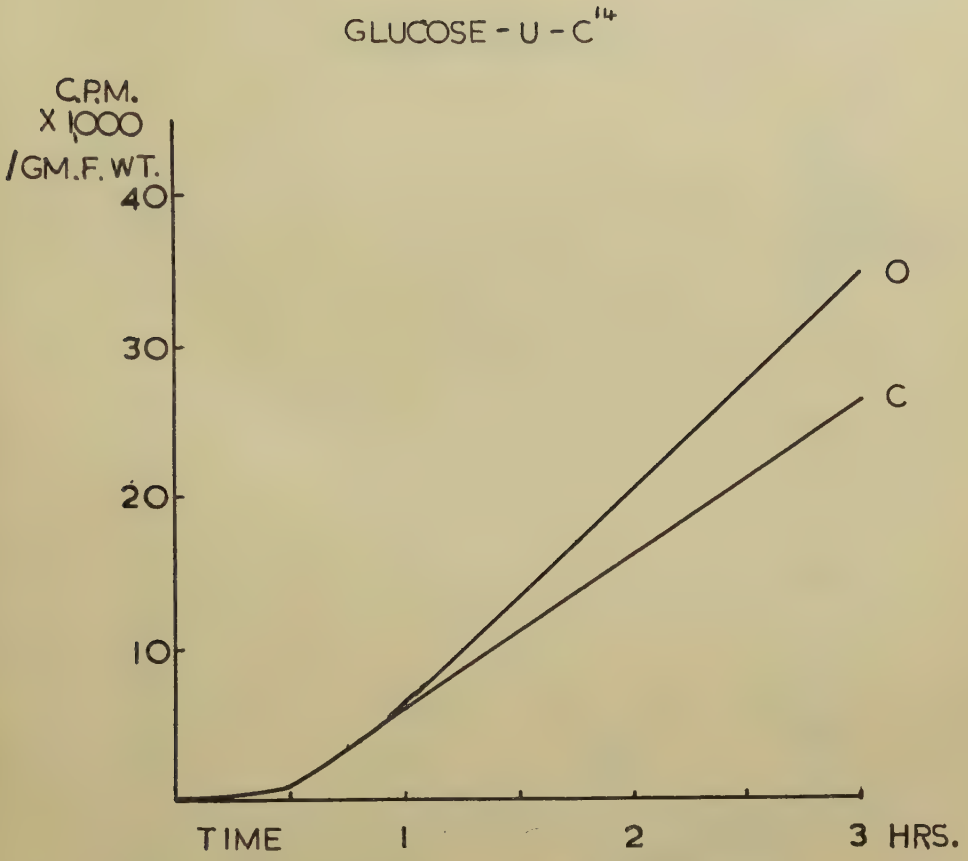

Fig. 2. Respiratory $^{14}CO_2$ output from lupin leaves with Glucose-R-^{14}C as exogenous substrate.

To investigate the nature of the increase in respiration, experiments were carried out using specifically labelled sugars as substrates rather than glucose -R-^{14}C. The use of specifically labelled sugars enables one to distinguish the various pathways involved in respiration. To date, glucose -1-^{14}C and glucose -6-^{14}C have been used as substrates. The $^{14}CO_2$ evolution patterns are given in Figs. 3 and 4.

The results show that the respiratory mechanism in lupin leaves can distinguish between the first (C1) and sixth (C6) carbon atoms of glucose molecules both in the iron deficient and normal tissues. The

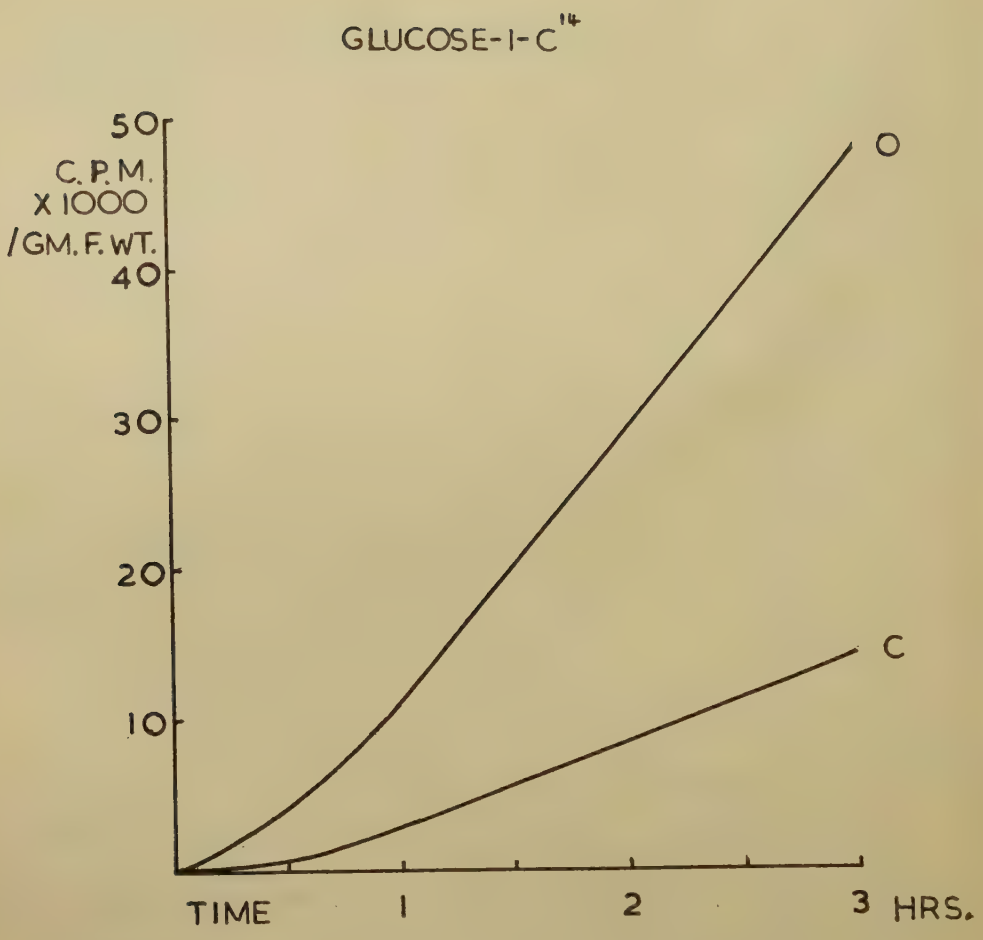

Fig. 3. Respiratory $^{14}CO_2$ output from lupin leaves with Glucose-1-^{14}C as exogenous substrate.

ratio of the radioactivity released from glucose -1-^{14}C to that released from glucose -6-^{14}C was constant after the first 40 minutes of the incubation period. The C1/C6 ratios after one hour for normal and deficient material were 10 and 13 respectively. This suggests that a greater proportion of the respiration of deficient material is by an alternative route, such as the pentose phosphate pathway[4].

These preliminary findings are being investigated further.

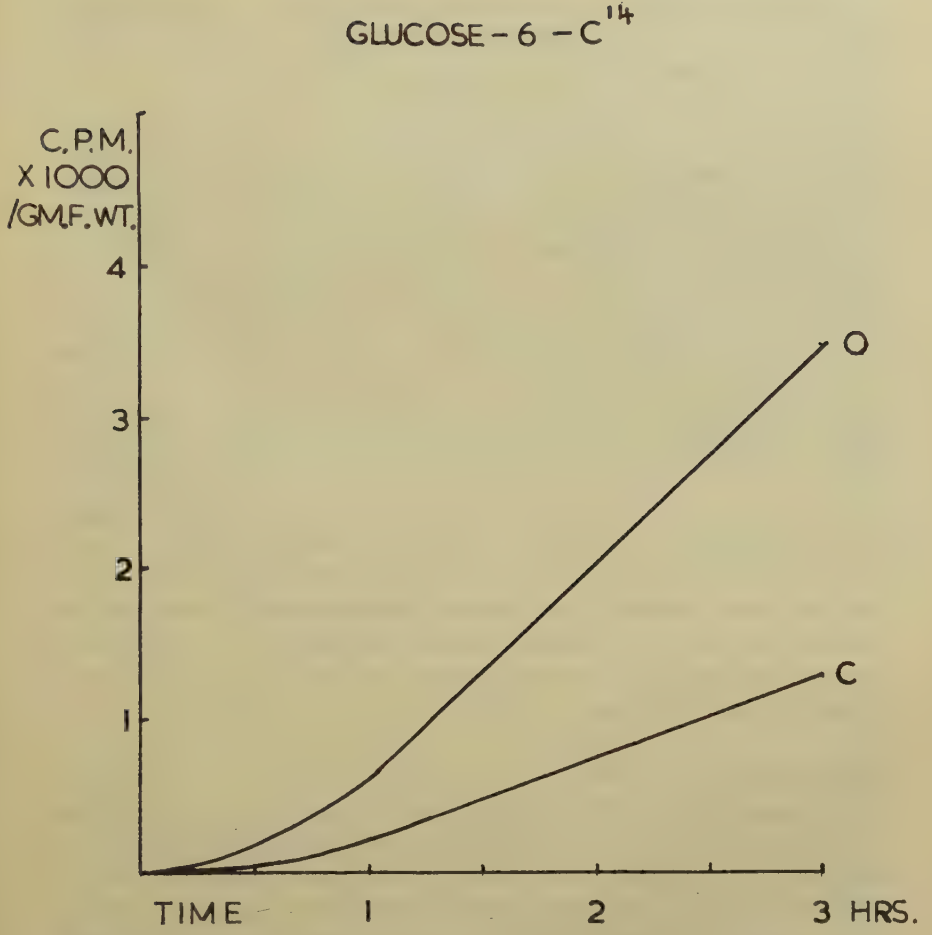

Fig. 4. Respiratory $^{14}CO_2$ output from lupin leaves with Glucose-6-^{14}C as exogenous substrate.

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THE LOW TEMPERATURE REQUIREMENT OF RHUBARB BEFORE FORCING

A. Loughton

Rhubarb for forcing is normally grown for two or three years in the field before dormant "roots" are lifted in the autumn and winter and then transferred to heated dark structures, where the forced "sticks" (i.e. etiolated petioles and leaves) are produced. Forcing is only successful if plants have been exposed in the field to a period of sufficient low temperature to break completely the dormancy of the buds. Past work, recently reviewed[1], has shown that if roots are forced before the required amount of cold treatment has been received then yields of forced sticks are reduced. No attempt has been made in the past to assess the critical requirements of low temperature to break dormancy, and growers have relied on empirical estimates for the correct time to lift roots. Experiments have shown that an error of even a few days in estimating the correct time for lifting may lead to a considerable loss of crop, especially in mild seasons. The object of the work described here was to devise a practical method of assessing the exposure to natural low temperature required for complete breaking of dormancy of rhubarb to ensure that a maximum crop of forced rhubarb could be produced in the West Riding of Yorkshire.

Lifting Date Experiments

The first step, in 1956, was to examine experimental records over a number of years showing the performance, as measured by final yield, of roots lifted for forcing at different dates throughout the late autumn. The results revealed typical sigmoid curves when yields were plotted against dates of lifting. Early liftings gave a poor yield but there was a rapid rise from later liftings until finally a point was reached where the yield curve levelled out. This point presumably indicated that dormancy had been completely broken before roots were lifted and also showed the earliest lifting date at which a maximum forced crop could have been obtained in any particular season. The dates of these optimum points varied from year to year and appeared to be related to the temperature conditions which prevailed during the season of lifting.

Controlled Temperature Experiments

In order to measure the total cold requirement it was essential first to determine the base temperature below which low temperatures are effective and cumulative in breaking dormancy of rhubarb. Experiments were conducted in 1956/57 and 1957/58 using the variety Prince Albert,

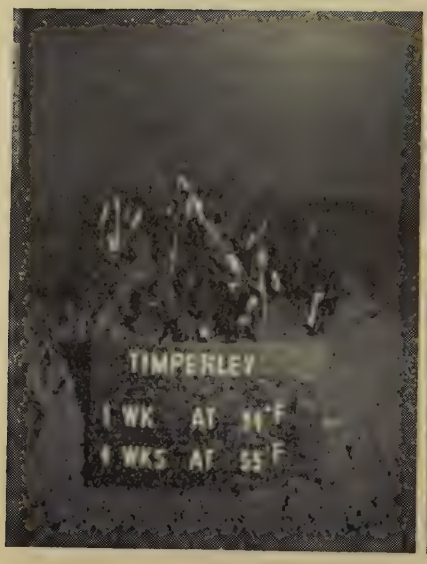
and in 1959/60 using Timperley Early and Victoria. Dormant roots were subjected to varying periods of artificially-induced cold in temperature controlled rooms before they were forced. Two temperature regimes were used and throughout the critical experiments roots were kept at about 34°F and 41°F, the period of exposure ranging from four days to ten weeks, depending on variety. The base temperature was determined by equating "inputs of cold" which resulted in the same yield, as measured in day-degrees, i.e. the number of days of cooling multiplied by the number of degrees by which the temperature was below a chosen base. The calculation of a base temperature was largely a process of trial and error but for all three varieties tested a base temperature of 49°F was found to satisfy the requirements and produce consistently satisfactory results. A complete range of yields from nil to maximum was generally produced in the various experiments, and there was an almost linear response over the middle portion of the yield range after precooling at 41°F.

In 1956/57 a small pilot trial indicated that temperatures below freezing were relatively ineffective in breaking dormancy, findings that are in general agreement with those of other workers on this question (2 and 3).

One interesting finding was that there is a relation between low temperature treatment and skin colour of the forced sticks. Briefly, exposure at 41°F induced a superior colour compared with 34°F, but within the 34°F treatment a short exposure to this temperature caused a deeper colour to develop than longer exposures. The same pattern was observed in experiments on lifting dates, i.e. early liftings produced better coloured rhubarb than late liftings. In all cases the trend was the same, i.e. a short exposure to low temperature led to low yield but good colour.

Summation of Low Temperature

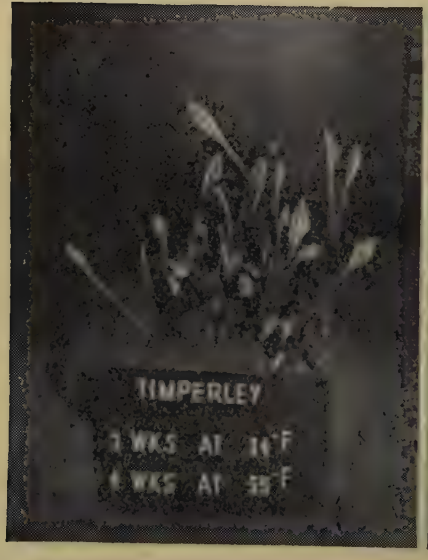
A number of practical and economic principles governed the choice of method of measuring low temperature in the field and of calculating the "temperature sum". The method finally adopted was based on daily readings (at 9 a.m. G.M.T.) of a four inch soil thermometer sited in bare ground. The use of such an instrument has a number of advantages, e.g. it is relatively cheap, easy to install, and no daily zeroing is required. Moreover, a 4 in. soil thermometer gives accurate readings almost immediately after installation, and there is thus no need to establish it long in advance of the first recording. This is particularly useful in a rhubarb field since the thermometer need not normally be put in place until the leaf cover begins to die down. Soil temperature at four inches


TIMPERLEY
1 WK AT 44°F
4 WKS AT 55°F

(a)

TIMPERLEY
2 WKS AT 36°F
4 WKS AT 55°F

(b)


TIMPERLEY
3 WKS AT 44°F
4 WKS AT 55°F

(c)

TIMPERLEY
4 WKS AT 36°F
4 WKS AT 55°F

(d)

(e) (f)

RHUBARB FORCED AT 55°F AFTER BEING GIVEN VARIOUS LENGTHS OF TIME AT 34°F

(a) 1 week (b) 2 weeks (c) 3 weeks (d) 4 weeks (e) 5 weeks (f) 6 weeks.

is observed as a routine at 9 a.m. G.M.T. in all crop weather stations of the Meteorological Office and past records thus already exist for much of the country.

Since the experiments described above suggested that only temperatures below 49°F contribute to breaking dormancy it was decided that summation of low temperatures should commence when the four inch soil temperature at 9 a.m. G.M.T. fell below 49°F. Daily differences between the observed reading and the base were accumulated, any readings above 49°F being disregarded, to produce a record of "cold units" as follows:—

Date	Soil temp. at 4in. 9 a.m. G.M.T.	Degrees below base of 49°F.	Accumulated total of cold units
1	50	—	—
2	47	2	2
3	45	4	6
4	46	3	9
5	51	—	9
6	49	0	9
7	47	2	11

Definition of Optimum Lifting Stage

The final stage of this work was to define the optimum stage for lifting from the field, i.e. the date by which the dormancy of the plants is likely to have been completely broken, in terms of accumulated low temperature measured in the manner described above.

The results of five seasons' experiments (1956-60 inclusive), using the variety Prince Albert, have been examined in relation to the level of accumulated low temperature at the time of lifting, and when the weight of forced crop is plotted against cold unit total at lifting, yield curves consistently reach a maximum at about 300 cold units. Similar experiments were conducted in 1958 and 1959, with both Timperley Early and Victoria, and the results indicate that the optimum lifting stage for Timperley Early occurs at about 200 cold units and for Victoria in the region of 450-500. (The response of Victoria will be investigated again during the winter of 1961-62).

The orthodox methods of accumulating temperatures, as used in Form 3300 of the Meteorological Office, are based on records of daily maximum and minimum air temperatures. A very close correlation ($r = +0.99$) has been found between the Meteorological Office method and the technique suggested here, at least for the period October to December, regardless of whether the cold units are compared with day-degrees based on air temperature or soil temperatures.

It appears, therefore, that, at this particular time of the year, the low temperature conditions of the macroclimate are accurately reflected by the corresponding conditions in the upper layers of the soil. This new technique for calculating cold units, which has simplicity as a main virtue, appears to be quite adequate for the purpose of estimating when roots of rhubarb have received sufficient cold to break dormancy. This should enable rhubarb growers to estimate the optimum time for lifting forcing roots, at a capital expenditure of less than £2 for a soil thermometer. Apart from this major result, one of the most interesting findings to emerge is that, depending on the amount of low temperature experienced before forcing, the crop may vary from total failure to maximum yield. It is likely that growers in the past may often have suffered a loss of potential crop of which they were unaware. For instance, near the maximum yield premature lifting of only 3-4 days could cause a loss in crop of the order of 15 per cent, despite the fact that roots yielded 6-7 pounds each, which would normally be regarded as satisfactory.

ACKNOWLEDGMENTS

The experiments described here were conducted at Stockbridge House Experimental Horticulture Station of the Ministry of Agriculture, Fisheries and Food. Acknowledgment is made to the Ministry for the facilities provided and for permission to publish this report. Appreciation is also expressed to the staff of the Station, particularly the Director, for assistance in this work, which was done in the course of part-time study for the degree of M.Sc. in the Department of Horticulture, University of Nottingham.

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CROP VARIETY TESTING

J. C. Llewelyn

N.I.A.B. Regional Trials Officer

The main series of variety trials conducted by the National Institute of Agricultural Botany at the School of Agriculture were continued in 1961 with few modifications to the previous year's programme.

The potato trials included recently introduced British varieties as well as a large number of foreign varieties of possible interest to British growers, and the trial to compare a stock of King Edward free from paracrinkle virus with seven commercial stocks was continued for a third year.

In addition to a full complement of winter and spring cereals, work continued with replicated trials of sugar beet, mangolds and fodder beet, rape, thousand head kale, marrow stem kale, silage maize, lucerne and grasses. Observation and demonstration plots of cereals and kale were also grown. Studies on the effect of cereal mildew on yield were continued in co-operation with the N.A.A.S., while yellow rust investi-

gations continued in collaboration with the Netherlands Grain Centre. Out-centre trials were again grown on the farm of Mr. W. Smith, at Wilson. These consisted of a winter barley and a silage maize trial.

The results of the main 1961 trials are summarised below. These by themselves have a limited application and should be used only as a very tentative guide to varietal performance.

Cereals

Although an extremely wet autumn caused difficulties the winter cereals were sown in good time and established and over-wintered well. Conditions were, however, too wet to sow a full programme of trials at the out-centre. Sowing conditions for spring cereals were excellent and once established all trials remained vigorous.

There was a moderate amount of mildew with only a slight infection of yellow rust. Many of the spring barleys had a considerable infection of loose smut and traces of loose smut also appeared in several winter wheat varieties. Take-all disease slightly affected all the spring wheat varieties but was more severe in Atle and Koga II.

In the Tables the main control variety is listed first with the yield in cwt. per acre. The yields of other varieties, with the secondary control listed first, are expressed as a percentage of the main control, and are in heavy type where they differ from it significantly (5% level). All yields are at 15% moisture content, and are the means of yields obtained at two levels of nitrogen.

WINTER WHEAT TRIAL

c/a=cwt. per acre

	Hybrid 46	Cappelle Desprez	Champlein	Falco	TB. 31/23	Vilmorin G.	Arromanches	Pevele x Vilmorin 29	Prestige	TB.106/40	3051 W.E.
c/a	38.2	102	102	101	102	105	97	92	95	97	104

Lodging was not serious but rather worse in Arromanches and Pevele x Vilmorin 29.

Yellow rust appeared in 3051 W.E. (International Scale 1).

Vilmorin G. was most susceptible to mildew.

WINTER BARLEY TRIAL

Proctor	HB.292/11/2/5	HB.292/73/2/2	HB.292/91/2/5
c/a 31.8	112	111	93

Trial drilled 22-2-61 and therefore PROCTOR used as control variety.
No lodging.

SPRING WHEAT TRIAL

Atle	Koga II	Jufy I	Fylby	Grano	Opal	Roter Lowe
c/a 27.9	104	123	107	112	121	112

SPRING OAT TRIAL

Sun II	Condor	Milford	Astor (Civ. 1688)	Flamingskrone	Marino	Vollbringer	MGH. 462	SV. 01760
c/a 29.9	117	86	114	113	106	95	97	99

Potatoes

After Majestic, which was the control in all trials, varieties are listed in order of their actual yields, with the highest yielding first.

Favourable weather during and after planting time resulted in all trials emerging well and growth was generally vigorous until severe frosts occurred on the 27th, 28th and 31st May. Although 60 to 95 per cent. of the total leaf area was completely destroyed most varieties had apparently recovered by the middle of June. Fortunately growth continued without check until blight appeared on the 5th September. This developed fairly rapidly and most varieties were completely defoliated by the end of the month.

The crop was finally harvested under ideal conditions. The quality of the tubers was generally of a high standard, but several of the foreign varieties were severely affected by tuber blight.

MAINCROP POTATO TRIAL

	Majestic	Pentland Crown	2319a	Ulster Glen	Ulster Ranger	H.42	King Edward	Seedling 120/18	Ulster Grove
Total tons/acre	21.24	21.70	20.82	20.42	20.35	20.22	19.48	16.38	12.91
Over 2"	16.92	18.36	11.48	15.53	16.84	17.47	10.80	11.1	7.35

FOREIGN VARIETY TRIAL: Seed ex. N. Ireland

	Majestic	Cherokee	Katahdin	Yampa	Seneca
Total (tons/acre)	20.16	17.85	17.20	16.99	15.00
Over 2"	16.21	16.28	15.12	14.72	13.15

FOREIGN VARIETY TRIAL: Seed ex. Cumberland

	Majestic	Saco	Kennebec	Sebago	Russet Burbank	Pungo
Total (tons/acre)	19.20	22.18	20.71	18.14	17.18	14.50
Over 2"	12.77	18.75	18.12	15.35	11.05	11.24

YELLOW FLESH VARIETY TRIAL

	Record	Orion	Solanum	Reaal	Bintje	Panther
Total (tons/acre)	20.33	19.89	18.31	17.48	16.88	16.69
Over 2"	13.84	15.42	12.57	11.37	8.43	9.08

	Ackersegen	Monica	Regent	Fruhperle	Rhondine
Total (tons/acre)	16.34	16.25	15.70	15.14	14.21
Over 2"	5.93	7.41	7.55	8.06	9.31

RATE OF BULKING—POTATO TRIAL

t/a=tons/acre

Date sprayed off	Majestic		Craigs Royal		Pentland Crown		Seedling 120/18	
	Total t/a.	Over 2"	Total t/a.	Over 2"	Total t/a.	Over 2"	Total t/a.	Over 2"
17th July	5.67	0.58	5.79	2.13	6.92	2.13	5.35	0.35
31st July	10.17	3.82	11.16	4.38	11.18	6.81	8.98	2.15
14th August	14.01	9.24	17.46	11.62	15.14	10.90	13.73	7.15
28th August	15.58	11.30	18.38	13.82	17.90	14.28	15.26	9.89
11th Sept.	20.91	16.95	18.75	14.24	20.84	18.54	17.71	12.55

Sugar Beet

Sharpe's Klein E was the control in each trial and the data of other varieties are related to it as a percentage.

MAIN SUGAR BEET TRIAL

	Sharpe's Klein E	Battle's Polyploid A	British Grown Klein E	Bush Monogerm Triploid	Desprez TM.	Garton's E.	Logie Polycross	Polyrave	Zwaanpoly
Population/acre	30,000 (100)	97	102	97	105	103	110	96	104
Bolters %	0.40	1.00	0.60	11.00	<0.10	0.80	<0.10	0.90	0.60
Yield of Tops t/a	15.3 (100)	103	108	106	102	107	110	107	106
Yield of Washed Roots t/a	19.5 (100)	99	96	78	96	100	86	98	103
Sugar %	14.4	15.4	13.6	14.5	15.0	16.2	16.4	14.0	16.3
Yield of Sugar t/a	2.8 (100)	106	91	78	100	112	98	96	117

SMALL SCALE SUGAR BEET TRIAL

	Sharpe's Klein E	Battle's Polyploid B	Bush Triplex H.S.	Dieckmans E. Maxima	Maribo N.	Multaverna	P. Poly	Webb's No. 392
Population/acre	32,200 (100)	93	91	101	100	97	97	99
Bolters %	0.70	3.50	1.30	4.70	1.70	1.50	5.70	2.10
Yield of tops t/a	16.1 (100)	102	104	103	101	108	97	97
Yield of washed roots t/a	20.4 (100)	96	89	87	78	85	74	96
Sugar %	16.1	16.0	16.5	15.7	17.6	16.3	17.5	15.8
Yield of Sugar t/a	3.29 (100)	96	91	85	85	86	81	94

THE INCREASE IN BARLEY-GROWING AND ITS REGIONAL PATTERN

D. K. Britton

England and Wales : The Total Picture

In 1961 the acreage of barley in England and Wales rose sharply for the fifth successive year. From 2.1 million acres in 1956 it soared to 3.4 million in 1961. The increase in this last year was the sharpest of all, being a jump of 344,000 acres in a single year. Even the urgency of the war-time switch to grains in 1940 did not result in such a dramatic rise as this, though in that year barley increased by 308,000 acres.

There were special reasons for the record high acreage of barley in 1961. Autumn ploughing and sowing were virtually impossible in 1960 in many districts, with the result that spring barley was sown in 1961 in place of the intended winter wheat. But this alone will not explain the expansion, which has been going on without interruption since 1956. We are evidently witnessing one of those broad, continuing changes in the pattern of British agriculture which only a long-term study can fully reveal.

Barley-growing in England and Wales, in the period since statistics began to be collected in the 1860's, can be seen to fall into three main phases. First, a period of stability or slowly rising acreage, 1867-1879; then a long and steady decline for nearly 60 years, during which the acreage fell from 2.4 million acres in 1879 to three-quarters of a million acres in 1933 (interrupted by a temporary and not very significant war-time expansion between 1915-1920); and finally a phase of vigorous expansion from 1933 to the present time, interrupted only by a five-year " pause " from 1946 to 1951 when barley was to some extent displaced by mixed corn.

It was in 1957 that the barley acreage exceeded for the first time the previous record which had stood since 1879. Thus in 24 years (1933-57) the long decline which had persisted almost unbroken for 54 years (1879-1933) was made up.

For farmers to have exceeded the barley acreages which prevailed in the " golden age of English farming " is all the more notable when it is remembered that the total area of farm land has fallen year by year with the spread of urban development. In the past sixty years nearly 3 million acres of crops and grass have disappeared entirely from agricultural use.

Looking at barley in relation to other cereals (see Charts I to III), a significant turning-point seems to have been reached in 1945. In that year barley's share in the total cereals acreage suddenly jumped to 28.5 per cent., after having stood at an average of 21 per cent. over the previous twelve years.

Since 1950, while the total cereals acreage has tended to fall, barley has increased in a spectacular way, bringing its share to 54.8 per cent. in 1961—the first year on record in which barley has exceeded all other cereals together.

It will be interesting to see whether this share can go any higher. Favourable margins between receipts per acre (whether through direct sale or indirectly through feeding to livestock) and costs of production have undoubtedly stimulated barley-growing in recent years, but there must be a limit to the amount which the market can absorb and to the area of land which is really suitable for this crop. Time may show that one or other of these limits has now been reached, though it may be noted that in two other countries, Norway and Denmark, barley prevails over all other cereals by a wide margin, its share of the total being 67 and 64 per cent. respectively. (Source: F.A.O. Production Yearbook 1960, using average of figures for 1958 and 1959).

Chart I—Barley Acreage, 1920-1961. England and Wales.

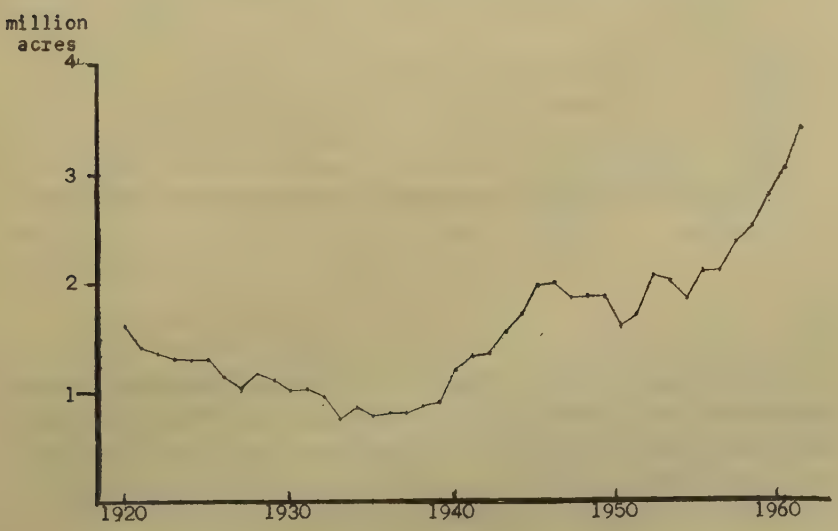


Chart II—Acreage of Other Cereals, 1920-1961. England and Wales.

Chart III—Barley as Percentage of Total Cereals, 1920-1961. England and Wales.

Another point of interest is that the proportion of farm land devoted to cereals has remained very stable around 25 per cent. for the past seven years (See Table I, column (3)). The expansion of barley has been at the expense of other cereal crops but—taking the country as a whole—it has not had a significant impact on non-cereal crops.

TABLE I

CEREALS IN ENGLAND AND WALES, 1870-1961

	(1) Barley as percentage of total crops and grass acreage	(2) Barley as percentage of total cereals acreage	(3) Cereals as percentage of total crops and grass acreage
1870	8.2	29.1	28.1
1880	8.2	32.3	25.0
1890	6.8	30.8	22.1
1900	6.3	30.9	20.6
1910	5.4	28.5	19.8
1920	6.2	27.2	22.7
1930	4.0	23.6	17.0
1940	5.0	23.1	21.5
1950	6.6	24.1	27.6
1955	8.6	35.3	24.4
1956	8.7	33.9	25.6
1957	9.8	39.2	24.9
1958	10.3	40.9	25.2
1959	11.5	46.8	24.5
1960	12.5	48.0	26.0
1961	13.9	54.8	25.4

Changes in number of growers

It may be asked, has the expansion taken place because more farmers are growing barley than was formerly the case, or has it been due to an increase in acreage on the part of traditional growers?

Figures collected and analysed by the Ministry of Agriculture, Fisheries and Food suggest that both these changes have been taking place simultaneously. Between 1955 and 1960 the number of agricultural holdings on which barley was grown increased from 81,000 to 91,000. There was practically no change in the number of growers of less than 20 acres of barley, but the number growing 20 acres or more increased from 28,000 to 38,000 in this five-year period.

The acreage per grower is increasing year by year and this trend is no doubt favourable to, and a consequence of, more mechanised harvesting. Moreover the acreage is tending to become more concentrated in the hands of the largest growers. In 1960, holdings on which at least 100 acres of barley were grown accounted for 40 per cent. of the total barley acreage, although they represented only seven per cent. of the growers. In 1948 the corresponding figures were 30 per cent. and 3.7 per cent. respectively.

Concentration of acreage has, in fact, gone somewhat further with barley than with wheat and much further than with oats. In 1960, the top 10 per cent. of growers of barley (i.e. those with the largest acreages) accounted for 48.9 per cent. of the acreage of that crop; for wheat the corresponding figure was 44.5 per cent. and for oats about 32 per cent.

Regional Changes

Study of the acreage statistics for the individual counties of England and Wales has established the following points:

1. Barley has always been a more important crop in the East and South of England than in the West and North or in Wales, mainly for reasons of climate and soil. The consistently "specialist" area is located in the counties of Norfolk, Suffolk and Cambridgeshire (excluding the Isle of Ely), with Lincolnshire (except the Holland Division), Essex and the East Riding of Yorkshire not far behind them—though Lincolnshire has tended to fall back relative to the "leaders" in this respect, while Hertfordshire, Hampshire, Berkshire and Bedfordshire have come more and more into prominence in the last thirty years.
2. When the barley acreage declined in the 1920's and early 1930's, the effect was felt more in the "non-specialist" than in the "specialist" counties. Conversely, the rapid expansion since the middle 'thirties has been more pronounced in the non-specialist counties. In other words, barley-growing was more locally concentrated during the depression years than it is today (see Table II).

TABLE II

BARLEY ACREAGE IN CERTAIN AREAS OF ENGLAND AND WALES

	"Specialist" Area (Norfolk, E. & W. Suffolk and Cambridge)		Secondary "Specialist" counties[1]		Other Counties	
	acres (000)	% of England and Wales barley acreage	acres (000)	% of England and Wales barley acreage	acres (000)	% of England and Wales barley acreage
1920	366	22.3	425	26.0	846	51.7
1930	326	31.9	302	29.6	392	38.5
1934	301	34.9	268	31.2	292	33.8
1940	397	32.6	371	30.4	451	37.0
1950	434	26.7	494	30.4	695	42.9
1960	608	19.9	916	29.9	1535	50.2

[1]Lincolnshire (except Holland Division), Essex, East Riding of Yorkshire, Hertfordshire, Hampshire, Berkshire and Bedfordshire.

NOTE: Before 1920, separate figures are not available for the three divisions of Lincolnshire, nor for Cambridgeshire apart from the Isle of Ely.

3. The fall and rise of barley-growing in the " non-specialist " areas has been far from uniform. In particular, the counties of Wales have never restored to barley the acreages which they lost in earlier years. In Cardiganshire, for example, 18 thousand acres of barley were grown in 1890; by 1934 this had fallen to seven thousand and in 1960 only a little over three thousand acres were grown. In several Welsh counties less than one per cent. of the farm land (excluding rough grazings) is now devoted to barley. It is quite clear that the factors which have encouraged barley-growing in most parts of the country in recent years have generally not operated in Wales, nor in certain counties bordering Wales and other counties with considerable areas of hill land and high rainfall. A very sharp increase in Cornwall, however, is noticeable between 1950 and 1960.

4. The swing back into barley after the mid-1930's showed a distinct movement southwards, as is shown by the figures in Table III.

TABLE III

BARLEY ACREAGE IN SOME SOUTHERN COUNTIES

	Counties of Bedford, Buckingham, Berkshire, Wiltshire, Hampshire (including Isle of Wight), Surrey and Sussex.	
	acres (000)	% of England and Wales acreage
1890	213	11.2
1900	166	9.5
1910	121	7.9
1920	128	7.8
1930	71	7.0
1934	56	6.5
1940	100	8.2
1950	227	14.0
1960	514	16.8

5. As well as this swing southwards, and the recent expansion in Cornwall already mentioned, there has been an exceptionally rapid development in the last ten years in parts of the north-western area, Cheshire in particular having far exceeded the acreages recorded before the agricultural depression (see Table IV). However, these counties are still of minor importance when compared with the " specialist " eastern counties. Nevertheless, the reasons for their recent dramatic increases might be worth investigating.

TABLE IV

BARLEY ACREAGE IN SOME NORTH-WESTERN COUNTIES

	Cheshire		Lancashire		Derbyshire	
	acres	% of England & Wales acreage	acres	% of England & Wales acreage	acres	% of England & Wales acreage
1890	1679	0.1	7157	0.4	8305	0.4
1900	1630	0.1	6321	0.4	6133	0.4
1910	1162	0.1	4427	0.3	4911	0.3
1920	3092	0.2	6280	0.4	7522	0.5
1930	533	0.1	986	0.1	2276	0.2
1934	282	0.0	404	0.0	1226	0.1
1940	1124	0.1	1090	0.1	2889	0.2
1950	1693	0.1	2220	0.1	3907	0.2
1960	15856	0.5	16414	0.5	13340	0.4

6. A final exception which may be noted is that of the fenland areas covered by the Isle of Ely and the adjacent Holland Division of Lincolnshire, where the eclipse of wheat by barley has not taken place as in other counties in East Anglia.

TABLE V

BARLEY AND WHEAT IN FENLAND COUNTIES AND IN OTHER COUNTIES OF EAST ANGLIA

	Isle of Ely and Lincolnshire (Holland)			Norfolk, Suffolk, Cambridge and Essex		
	Barley acres (000)	Percentage of Crops and Grass area devoted to:		Barley acres (000)	Percentage of Crops and Grass area devoted to:	
		Barley	Wheat		Barley	Wheat
1920	36	8.1	17.6	430	15.0	13.1
1930	22	4.9	17.2	386	14.1	11.0
1934	10	2.0	19.9	363	13.6	14.0
1940	20	4.4	21.2	482	18.1	12.5
1950	21	4.7	26.3	532	19.9	15.2
1960	39	8.6	27.2	764	28.3	17.0

Summary

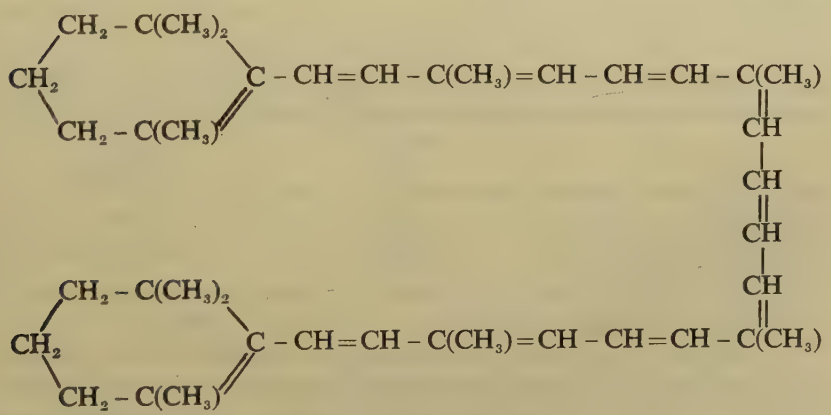
The barley acreage of England and Wales has increased very rapidly. There are more growers and larger acreages per grower. The cultivation of this crop has spread considerably in counties not hitherto regarded as "specialist" for barley, especially in southern England.

THE EFFECTS OF DIET UPON EGG YOLK PIGMENTATION

J. Stevens and D. Lewis

During the last decade there has been a progressive decrease in the proportion of eggs that come from birds maintained under free range conditions with access to grass. At the same time battery and deep litter systems have developed which usually involve the feeding of rations that contain less pigment. The eggs produced often have paler yolks and this has led to a concept of a poorer despised egg. It has also necessitated an examination of the fate of dietary pigments in the laying hen.

The pigments of egg yolks are carotenoids. The basic structure of these compounds involves a group of isoprene units joined end to end to give a conjugated unsaturated system responsible for the colour. They can form β-ionone rings at either end. The carotenoids may be wholly hydrocarbon and termed carotenes or may have hydroxyl substituents when they become xanthophylls.



β – carotene

Egg yolk colour is largely due to xanthophylls but β-carotene is also present and may account for 1—10% of the total. The β-carotene is, however, a precursor of vitamin A whereas the xanthophylls are not. The xanthophylls are a mixture of lutein and zeaxanthin [1] in a ratio of 7:3; this has been confirmed in the present studies. Gillam and Heilbron[2] claimed that the alleged carotene fraction was mainly kryptoxanthin, also a precursor of vitamin A, and found this material accounted for less than 4% of the total carotenoids. In the present studies kryptoxanthin has not been demonstrated in egg yolk.

No important function has been demonstrated for xanthophylls and their deposition in egg yolk seems to be mainly a convenient means of disposal. Since yolk contains a considerable amount of lipid the fat soluble xanthophylls are easily deposited. Similarly fat depots, especially of older hens, are often yellow. Grimbleby and Black[3] showed a relationship between total carotenoids and vitamin A content suggesting that the presence of xanthophylls had some effect. However, Palmer and Kennedy[4] fed a carotenoid-free diet to hens until egg yolks without pigment were produced: the eggs were normal in all other ways.

Pigmentation of egg yolk when the birds receive the same diet varies with breed, age and the individual. When these factors are standardised the diet influences pigmentation. Though it is often considered that any dietary pigment appears in the egg, this is an over-simplified viewpoint. It is known for example that the proportion of pigment that becomes ultimately located in the egg is not constant (Table 1). Added synthetic pigments are also utilized for yolk pigmentation to a variable extent. Violaxanthin for example is ineffective, zeaxanthin and isozeaxanthin dimethyl ether give good pigmentation whilst lutein is rather less effective.

TABLE 1

RELATIVE PIGMENTATION OF EGG YOLK WITH DIFFERENT ADDED SOURCES OF PIGMENT[5]

Foodstuff	Xanthophyll content mg/lb.	% location in egg relative to yellow corn
Yellow corn	6.7	100
Dehydrated alfalfa meal	250	25
Maize gluten meal	80	50

A possible cause for the different degrees of deposition of pigment in egg yolk may be differing susceptibility to oxidation. Carotenoids as a whole are fairly easily oxidised, and oxidation can conceivably occur on storage of the food, in the intestine or after absorption. Several factors have in practice been found to influence pigmentation in a manner that might be related to differential oxidation. The vitamin E content of food is often claimed to protect pigments against oxidation. Lettuce, with a high vitamin E content, shows a good utilization of carotenoids for yolk pigmentation. Conversely it has been claimed that xanthophylls protect vitamin E. Several added constituents e.g. fish oils, hydrolysed fats, meat scrap meals have been alleged to decrease pigmentation and antioxidants are thought to increase pigmentation. There is, however, very little precise data available upon the effect of dietary constituents on egg yolk pigmentation.

A method has been developed for the extraction and analysis of egg yolk pigments. Absolute alcohol is added to a sample of yolk to facilitate protein precipitation and the pigment is extracted using a mixture of equal volumes of petroleum ether and di-ethyl ether. The ether is removed and absolute alcohol added: following the addition of aqueous potassium hydroxide the mixture is heated on a water bath. To prevent oxidation all operations involving heat are carried out in a stream of nitrogen. A separation is now effected between an ethereal and saline layer and the pooled ether extracts carefully washed. Sterols and lipid materials that might interfere with the carotenoid estimation pass to the aqueous layer. The pigments are transferred to light petroleum ether and the total carotenoids are assessed by measurement of the optical density at 455 m.μ. Vitamin A is determined by taking an aliquot, re-dissolving in cyclohexane and measuring the optical density at several wavelengths. The vitamin A calculation is made by the method of Morton & Stubbs.[6]

The petroleum ether fraction is applied to a magnesium oxide-celite column: the β-carotene is eluted with light petroleum and the xanthophylls with absolute alcohol. The ratio of carotene to xanthophyll is assessed by measuring the optical density in light petroleum at 445 and 449 m.μ. respectively. The lutein and zeaxanthin are separated on similar columns by elution with various light petroleum, acetone, alcohol mixtures.

This procedure was tested on several samples of egg yolk. A typical selection of values for three eggs randomly obtained from different birds fed different rations is given in Table 2. Duplicate values of total carotenoids were obtained, the mean being quoted. The duplicates differed by less than 3% in all cases. A determination of total carotenoid

TABLE 2

PIGMENTS OF EGG YOLK EXPRESSED AS mg per gm EGG YOLK x 10^3. VALUES GIVEN FOR 3 EGGS FROM DIFFERENT BIRDS FED DIFFERENT DIETS. COLOUR NUMBER REFERS TO AN ARBITRARY COLOUR SCALE.

βcar=βcarotene: zeax=zeaxanthin: xanth=total xanthophyll

Egg	1	2	3	Mean
Colour number	6½	7	7½	7
Total carotenoids	21.5	24.4	32.0	26.0
Ratios:				
βcar: xanth	1:16	1:16	1:16.5	1:16.2
zeax: lutein	1:2.0	1:2.1	1:2.1	1:2.1
βcar: zeax	1:5.8	1:5.0	1:5.4	1:5.4
βcar: lutein	1:11.3	1:10.6	1:11.3	1:11.1

was also carried out on a group of eggs laid by the same bird over a period of 10 days. The results are shown for two such hens in Table 3 and indicate a characteristic pigment level for each hen, though there is a fairly large range of variability from egg to egg. The visual colour method shows some relationship to the analytical values but not a consistent correlation. Other factors such as colour of albumen and thickness of yolk membrane have an effect. However, the visual index reflects the characteristic required by the consumer.

TABLE 3

TOTAL CAROTENOIDS OF SUCCESSIVE EGGS FROM THE SAME HEN. TWO WHITE LEGHORN BIRDS WERE USED NEAR THE END OF THE LAYING SEASON AND WERE FED A STANDARD COMMERCIAL LAYERS' RATION.

Hen A		Hen B	
Visual colour chart	Total caroteniods mg/gm yolk x 10^3	Visual colour chart	Total carotenoids mg/gm yolk x 10^3
5½	17.0	4½	12.1
4½	15.7	4	11.1
5½	18.8	3½	12.4
5	15.7	5	14.7
5	13.8	5	15.8
5½	17.9	5	15.6
		4	11.4
Mean	16.5	Mean	13.8

A field trial has been carried out to determine the effect of several dietary factors upon yolk colour. A group of 48 White Leghorn birds were used during their first laying season. There were 8 different experimental treatments and 2 cages of 3 birds per treatment. All the birds were fed a standard commercial layers ration for a preliminary period of two weeks. Groups of six eggs from each cage were collected and total carotenoids determined on the pooled yolks. Selected results are given in Table 4 and show a fairly uniform total pigment level. The eight groups were changed to the experimental rations (Table 5). The basal ration (16% protein) contained 37% wheat meal, 36% yellow maize meal, 13% soyabean meal, 6% maize gluten meal, 3% limestone and a supplement (5%) that supplies various minerals, vitamins and other minor constituents.

After the introduction of the experimental treatments all the eggs were collected and a visual colour assessment made. Complete analysis was carried out on a sample obtained from mixed yolks of six eggs per treatment weekly. Full records are also kept of total egg weight and food consumption. An indication of the results is included in Table 6, which gives the visual colour index of a random selection of eggs laid

during the third week on the experimental treatments. The presence of antioxidant encourages pigmentation, oleic acid seems to have little effect and the added pigment has increased the depth of colour. The next experiment will use a basal ration of lower natural pigment and also lower vitamin E potency.

TABLE 4

TOTAL CAROTENOIDS OF GROUP OF BIRDS MAINTAINED ON A STANDARD DIET PRIOR TO ESTABLISHMENT OF EXPERIMENTAL PROGRAMME DETAILED IN TABLE 5.

Group	Total carotenoids mg/gm yolk x 10^3			Mean
S1	23.4	24.3		23.8
S2	25.2	22.2	22.6	23.4
S3	28.4	27.7		28.0
S4	22.3	22.7		22.5
S5	22.3	19.4	22.8	21.5
S6	27.8	27.0		27.4
S7	23.4	25.0		24.2
S8	23.8	24.1	22.4	23.4

TABLE 5

EXPERIMENTAL TREATMENT IN FIELD TRIAL BHT=0.0125% BUTYLATED HYDROXY TOLUENE (ANTIOXIDANT). OLEIC ACID=UNSATURATED FATTY ACID AT 2%. SP=β-APO-8-CAROTENOIC ACID ETHYL ESTER AT 10 gms. per 1000 lbs. FOOD (SYNTHETIC PIGMENT).

S1	Basal	S2	Basal+BHT
S3	Basal+oleic acid	S4	Basal+BHT+oleic acid
S5	Basal+SP	S6	Basal+BHT+SP
S7	Basal+oleic acid+SP	S8	Basal+BHT+oleic acid+SP

TABLE 6

VISUAL COLOUR INDEX (ROCHE COLOUR FAN) OF EGGS LAID DURING THE THIRD WEEK IN THE FIELD TRIAL.

Treatment	Visual colour index	Mean
S_1	5 5½ 5½ 5 5½ 5 5 5½ 5 6½ 6½	5.5
S_2	5½ 5½ 5½ 6½ 6 5½ 5½ 5½ 6 6½ 6½ 7½	6.0
S_3	5½ 6 5½ 5½ 5½ 6 6 5½ 6½ 5½ 5½ 6	5.7
S_4	5½ 6 6½ 5½ 5½ 6 6½ 5½ 6 6 6	5.9
S_5	5½ 6 5½ 6 6 5½ 5½ 6 6 6½ 7½ 6½	6.0
S_6	6½ 6 6 6½ 6 6½ 7 7 7½ 7 6½ 7 7½ 7	6.6
S_7	6½ 7 6½ 7 6½ 6 7 6½ 7 6 6 6½ 6	6.5
S_8	6½ 6½ 7 6 7 6 7 6½ 6½ 6½ 6½ 7	6.6

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THE USE OF HORMONES TO INDUCE EXTRA-SEASONAL BREEDING IN SHEEP

G. E. Lamming

In a previous contribution the main factors which have limited the productivity of British breeds of sheep were reviewed and one section dealt with experiments on the use of hormones to induce them to breed all the year round (Allen & Lamming, 1959). In the normal breeding season oestrous behaviour is confined to a period on either side of the shortest day, the length of the season being dependent upon the breed. The results of further experiments are now available, and these indicate that the methods used may have a wide commercial application in the near future.

The work has involved the use of a steroid sex hormone, progesterone, which can now be produced chemically, and a serum gonadotrophin. Pregnant Mare's Serum (P.M.S.) which is collected from pregnant mares between the 60th and 90th day of pregnancy. The earlier results showed that, following injections with these preparations, maiden sheep could be induced to breed six months earlier than normal. In the first experiments using lactating ewes few lambs were born although a moderate proportion of treated ewes showed oestrus.

Lactating ewes were then subjected to a treatment involving the artificial lengthening of the dark period during summer, thus simulating the decreasing day length which is known to be responsible for the onset

of the normal breeding season. Breeding activity was induced and fertile mating occurred but the technique was not practical on a farm scale and a long treatment period was required. On examination of the ovaries of the animals from this experiment it was noted that a "silent heat" had preceded the fertile heat, and it was thought that this was important in improving the subsequent fertility at the fertile mating compared with the results obtained at the first oestrus with hormone treatment. It was thought that the improved fertility was probably associated with the more adequate preparation of the reproductive tract to produce and support an embryo.

Since the single series of injections with progesterone and P.M.S. had been successful in maiden but not in lactating ewes, it was decided to simulate the silent heat by applying a double series of progesterone and P.M.S injections in the lactating ewes. We were fortunate to be offered some flocks of sheep for this work.

Four flocks were used in 1960 and in three the treatment involved splitting the available lactating ewes into two groups. In all ewes of these flocks 50 mg. progesterone was injected intramuscularly on Day 1, 4 and 7 and 850 i.u. P.M.S. on Day 9. In half the ewes (the "single" group) those which showed oestrus after Day 9 were allowed to mate with fertile rams. The rest were mated after the second series of injections of 50 mg. progesterone intramuscularly on Day 17, 20 and 23 with 850 i.u. P.M.S. on Day 25. In Flock No. 2 in which the lambs had been born early and which had been recently weaned, only the single series were given. The results of these treatments are shown in Table 1.

These results confirm that suckling tends to limit the success of the induced breeding activity. The double series of injections increased the incidence of oestrus, but although a greater percentage of fertile matings occurred in these groups, the results were still far from satisfactory. Several ewes which failed to become pregnant at the induced heat returned to service without further treatment 16 days later and some conceived. In the weaned Flock No. 2, the results were particularly encouraging and showed what might be achieved under ideal conditions. In all flocks 100 lambs were produced in the autumn of 1960 from 207 ewes treated.

During 1961 these experiments were continued in a large flock which contained ewes which had lambed in January, 1961, and others which had lambed four to six weeks later. During April the ewes of each batch were divided into three groups and the single and double treatment carried out as above on two of the groups. The third group comprised ewes which had already been weaned and some of these

TABLE 1

The production of lambs from lactating ewes during the non-breeding season 1960.

Flock No.	Date	Treatment	No. of ewes	No. mated	No. pregnant	No. of lambs	Comments
1	16.3.60	Single series* 3 x 50 mg. progesterone + 850 i.u. P.M.S.	21	16	4	7	12 ewes returned naturally in oestrus 16 days later; 8 lambed giving 10 lambs
		Double series† 3 x 50 mg. progesterone + 850 i.u. P.M.S. followed by 3 x 50 mg. progesterone + 850 i.u. P.M.S.	15	14	9	10	Total 27 lambs
2	28.5.60	Single series 3 x 50 mg. progesterone + 850 i.u. P.M.S.	30	28	26	36	2 died during pregnancy Total 36 lambs
3	22.4.60	Single as Flock 1	40	20	6	9	One additional ewe in each group aborted twin lambs.
		Double as Flock 1	40	29	10	14	Total 23 lambs
4	22.4.60	Single as Flock 1	30	10	0	0	7 ewes lambed, 16 days later producing 9 lambs
		Double as Flock 1	31	14	3	4	1 ewe lambed, 16 days later producing 1 lamb. Total 14 lambs

* Progesterone on Day 1, 4, 7. P.M.S. on Day 9.

†Progesterone on Day 1, 4, 7, 17, 20, 23. P.M.S. on Day 9 and 25.

Flocks 1 and 2 lambs weaned one to two weeks before treatment. Flocks 3 and 4 treated before weaning.

TABLE 2

Results of experiments with lactating sheep (Suffolk and Suffolk Cross) 1961.

Previously lambed	Single treatment				Double treatment				TOTAL				Already weaned			
	No.	On heat	Lambed	No. lambs	No.	On heat	Lambed	No. lambs	No.	On heat	Lambed	No. lambs	No.	On heat	Lambed	No. lambs
January, 1961	22	13	10	14	22	15	11	13	44	28	21	27	22	13	9	10
February, 1961	26	7	3	4	26	21	8	12	52	28	11	16	—	—	—	—
TOTALS	48	20	13	18	48	36	19	25	96	56	32	43	22	13	9	10

N.B.: Total for flock: 118 ewes; 69 on heat; 41 lambed; 53 lambs.

mated naturally, usually 2-3 days after weaning. It was considered desirable to compare their fertility with those treated with progesterone and P.M.S.

In addition to the lactating ewes, 50 maiden ewes were treated as described previously (Allen & Lamming, 1959) and a further 20 maiden ewes received their progesterone as an oral preparation—6αmethyl-17αhydroxy-progesterone acetate (Provera - Upjohn), given daily for 10 days. The lambs from these treatments were born within a short period in September, 1961, and a total of 121 lambs were born from 99 ewes providing a convenient flock worthy of special attention. The results of the different groups were as shown in Table 2.

The experiments with lactating ewes confirm that the double series of injections leads to a greater oestrus response and improves the conception rate, the January group responding better than those which had lambed later. There was no difference in the fertility of the treated ewes and those which mated naturally.

Of the 50 maiden ewes treated, 31 showed oestrus following the first treatment series and 13 subsequently produced lambs. The remaining 20 were treated for a second time and 16 showed oestrus and nine produced lambs. The total number of lambs from this group was 29. Of the 20 maiden sheep receiving progesterone orally, 10 came into oestrus and all produced lambs. Oral treatment with progesterone preparations may therefore offer a more convenient method of treatment, especialy where lactating ewes have to be treated twice.

Several important observations were made during the autumn of 1961 concerning this flock. In August all the lactating ewes had been weaned and these and the treated maiden sheep were run with raddled fertile rams. The sheep which mated (i.e. those not already pregnant) were removed from the flock to form the January lambing group for 1962. The 100 pregnant ewes remained as a small flock and received special feeding. The ewes lambed in two groups; in the first the maiden and single-treatment ewes, in the second the double-treatment groups, both periods extending to about four days with a few sheep producing lambs 16 days later.

The losses before and at parturition in the autumn were extremely low; one ewe died during pregnancy, one ewe aborted twins, two lambs died at birth and one died at about two months of age of unknown cause. The remaining 115 lambs were sold fat between 30.11.61 and 12.1.62—many for the Christmas trade.

The ewes and lambs grazed new leys until 1st November and thereafter were fed on kale. The ewes received 1-1½ lb. concentrates per day (one part Ewe and Lamb Nuts, two parts ground oats) from lambing

until the lambs were sold. As the lambs gained weight an increasing proportion of the concentrates offered were consumed by the lambs and the trough area was increased to facilitate this. The lambs also had access to creep feed and over the whole period they also consumed 25 cwts. purchased concentrates and 25 cwts. of ground oats and a similar quantity of ground barley.

Half the male lambs were not castrated and although these intact males made satisfactory growth, in future all male lambs will be castrated because these intact males tend to chase the oestrous ewes. Raddled and fertile rams were placed with the lactating ewes six weeks after they lambed and within two weeks most ewes had been mated even though lactating. These ewes will form the "late" groups for 1962 and will not be treated with hormones during 1962 and will enter the early group in 1963.

The average dead weight of the 112 lambs sold was 38.2 lbs. and they realised an average of £6 16s. 5½d. each, producing a total income of £764 3s. 0d. From this approximately £275 should be deducted for concentrate feeds, leaving £489 to pay for the extra labour, the cost of treatment and profit.

The methods used have allowed a revision of the management policy of the flock, designed to produce more lambs per ewe per year and the flock is now managed in two sections, an "early" and a "late" group. The maiden ewes are treated in the spring with hormones to lamb in the autumn, and based on past years approximately 50% will lamb in the autumn as a result of this treatment. The "early" ewe group (i.e. those which lamb in January and February) are also treated in the spring and approximately 50% should also respond to produce autumn lambs. In August, after all lambs have been sold fat or weaned, the maiden and lactating ewes are placed with fertile rams and those which do not mate are removed from the flock leaving the pregnant ewes to lamb in September. This prevents feeding concentrates unnecessarily to non-pregnant ewes and automatically provides the "early" group for the next year. Those which lamb in the autumn are then re-mated and become the "late" group. Most ewes lactating in the autumn as a result of this extra-seasonal breeding activity take the ram normally within 6-8 weeks of parturition. There have been no troubles with autumn lambing; the ewes lamb out on pasture and have an adequate supply of milk. However, concentrate feeding of the ewes and lambs is essential and creep feeding of the lambs must be maintained to achieve a high growth rate, in order to sell the offspring as fat lamb. If suitably fed their carcasses command a premium for quality and weight during the winter months.

All the ewes involved in these studies are being weighed and recorded, to determine the effects of treatment on productivity and longevity, and with a high standard of husbandry it is anticipated that, using these methods, the productivity of the flock can be substantially increased.

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AN ANALYSIS OF THE ACARINA AND COLLEMBOLA FAUNA OF LAND RECLAIMED FROM OPENCAST IRON-STONE MINING

B. N. K. Davis and P. W. Murphy

In recent years there have been a number of references to the use of soil animals as indicators of soil conditions (e.g. Murphy 1953) and attempts have been made to use these populations as an expression of some quality of the site such as productivity (Franz, 1949) or genetic soil group (Gilyarov, 1958) or the quality of vineyard soils (Gisin, 1955). Few of these studies have attempted a strict quantitative analysis and it is for this reason that this summary of an attempt to characterize three sites by the species of Acarina and Collembola occurring in them is presented.

The main site chosen for this investigation is an area which has been restored to agricultural use after opencast iron-stone mining. In Northamptonshire, where 400 acres are mined annually for iron-stone, considerable attention has been given by Messrs. Stewarts & Lloyds Minerals Ltd. to the problem of reclamation, and part of this study has been concerned with changes in the soil-animal population resulting from these restoration practices.

Three sites at Corby were sampled for this work. The first is an area of levelled but otherwise untreated quarry land having little vegetation apart from a sparse growth of Coltsfoot (*Tussilago farfara L.*), and a few grasses and prostrate herbs. The second is one of the oldest reclaimed fields, which has been under grass since 1948 and the third site is permanent grassland outside the area of quarrying operations. Two sampling stations (sides of 15-20 yards) were marked out on each site, and studies made of the soil, the vegetation, and the Acarina and Collembola fauna occurring in the uppermost three inches of the soil.

The soil in all the stations is a heavy clay but mechanical analysis indicated certain differences in the proportions of sand, silt and clay, and these are expressed by the ratio of sand to silt + clay (Table 1). Of the other soil properties studied, soil moisture, organic-carbon content and total pore space showed a steady increase from untreated quarry to old grassland while the pH values showed a reverse trend (Table 1). The root content of the top three inches of the restored grassland was greater than in the old grassland but there was very poor root development below this depth on the restored site.

TABLE 1

Some soil properties of levelled quarry, reclaimed land and old grassland at Corby, Northamptonshire (pH, organic carbon and mechanical analysis: mean values of 2 subsamples from 2 bulked samples of 10 cores, 3 in. deep).

Site	Sampling station	Moisture content* (per cent oven-dry weight)	pH	Organic-carbon content (per cent air-dry weight)	Mechanical analysis (ratio sand: silt+clay)	Total porosity† (per cent total volume)	Root content† ($g/100cm^3$)
Levelled quarry	A	20	7.7	1.6	0.94	46	0.1
	B	21	7.6	1.4	0.94	44	0.1
Reclaimed land	C	33	7.6	2.3	1.21	49	1.3
	D	31	7.5	2.6	0.51	54	1.3
Old grassland	E	56	6.0	3.8	0.71	62	0.9
	F	63	6.1	3.8	0.77	62	1.1

*Over-all mean values of 6 samplings (4 sampling units/sampling).
†Means of 6 sampling units (*d* 2 in. and 3 in. deep).

The soil fauna of each pair of sampling stations was sampled on six occasions between November, 1958, and June, 1959, and all the Acarina and Collembola present in 216 sampling units (*d* 2 in. and 3 in. deep) were identified wherever possible. The numbers recorded (Table 2) are not large when compared with other grassland surveys (cf. Salt, Hollick, Raw and Brian, 1948, for example). The fauna, however, proved to be very rich in species, the predatory Mesostigmata with 37 out of 81 species of mites being a particularly noteworthy group, although the oribatid mites were the most important group from a quantitative standpoint.

The salient features of the faunal survey of the six stations are summarized in Table 2. It was quickly realised that the number of species alone was not a very helpful guide to changes in the soil factors measured. The same applied to number of individuals because although there were noticeable differences among the six stations, these followed no clear pattern or sequence. It thus seemed essential that any analysis of plot similarities or differences should be made at species level, taking into

account presence or absence of the species in the sampling units. Fifteen of the most common species were selected and their co-occurrence in the soil cores was analysed. By grouping those species which occurred

TABLE 2

Numbers of Acarina and Collembola, and numbers of species, obtained from six samplings (November, 1958 to June, 1959) at Corby, Northamptonshire (total number from 36 cores (d 2 in. x 3 in. deep) per station)

Site / Animal group	Levelled quarry		Reclaimed land		Old grassland	
	A	B	C	D	E	F
Acarina—Oribatei	84	177	108	700	636	343
Acarina—others	406	470	465	483	438	483*
Collembola	497	500	711	332	993	647
Total	987	1147	1284	1515	2067	1473
Total species	54	58	51	48	61	53

*Excluding two exceptional aggregations of nymphs of Acaridiae totalling 171 specimens.

most often together it was possible to recognise three main communities. The old grassland was characterized by a well-knit group consisting of 2 oribatid mites (*Minunthozetes semirufus* (C. L. Koch) and *Scheloribates laevigatus* (C. L. Koch)) and 3 species of Collembola (*Isotomurus palustris* (Müller), *Onychiurus subarmatus* Gisin and *Tullbergia quadrispina* (Börner)). A second group of 3 springtail species, (*Friesea mirabilis* (Tullberg), *Isotoma notabilis* Schäffer and *I. viridis* Bourlet), occurred more or less equally in the other two sites. The third was a less well-defined group of 4 mite species (*Alliphis halleri* (G. and R. Can.), *Oppia quadricarinata* (Mich.), *Punctoribates punctum* (C. L. Koch) and *Tectocepheus velatus* (Mich.)), which showed a preference for station D (reclaimed land). Relating these faunal changes to trends in the soil factors over the three sites, it would seem that high values for soil moisture, organic carbon, pore space and low values for pH might be sufficient in distinguishing the old grassland from the other two sites. In the case of station D, however, the only distinguishing feature appeared to be the proportion of sand to silt and clay.

In order to obtain more direct evidence of the influence of these soil factors on the fauna, a multivariate technique of statistical analysis (canonical analysis) was used. By this means it was possible to take into account associations between species and between soil properties and thus to determine the interrelationships of these two expressions of soil status. Three species of mites (*Punctoribates punctum, Rhodacarellus silesiacus* Willm. and *Tectocepheus velatus*) and three springtail species (*Onychiurus subarmatus, Tullbergia krausbaueri* (Börner) and *T. quadrispina* (Börner)) were chosen for this purpose.

TABLE 3

Interrelationships of the numbers of two arthropod species and four soil factors in the sampling stations at Corby, Northamptonshire.

(See Table 1 for details of soil factors)

Site	Sampling station	*Tectocepheus velatus*	*Tullbergia quadrispina*	Organic-carbon content	Moisture content	Mechanical composition	Root content
Levelled quarry	A	Medium	Low	Low	Low	High	Low
	B						
Reclaimed land	D	High	Low	Medium	Medium	Low	High
	C	High	High	Medium	Medium	High	High
Old grassland	E	Low	High	High	High	Medium	Medium
	F						

The analysis indicated that of the soil attributes measured, pH, organic matter, pore space and soil moisture were highly important while mechanical composition and root content were less effective. Similarly one could rank the six animal species in order of their over-all response to these soil factors, and it appeared that the contrast in the distributions of *T. velatus* and *T. quadrispina* was particularly significant. If the sampling sites are considered as members of a developing series it will be seen that *T. velatus* increases in the reclaimed field (Table 3) but by the time the old-grassland stage is reached it is very much less important. With *T. quadrispina,* on the other hand, its first high value coincides with a similar value for *T. velatus* in station C (Table 3), and to this extent this station might be regarded as transitional between the reclaimed and treated area, and the old grassland. An interesting feature of Table 3 is the comparative insensitivity of the soil factors in characterizing the three sites especially when it is remembered that the analysis indicated that mechanical composition and root content were of lesser importance. The two animal species appear to have a greater discriminating power, and seem to reflect site differences which are not revealed by the soil factors. The differences between stations C and D are particularly interesting as the total faunal analysis indicated marked differences between these two stations.

The results of this attempt to characterize sites by their fauna suggest that the comparison of soils on the basis of animal populations is a feasible proposition provided that the analysis is dealt with at species level. It is evident from this example that single species are unlikely to characterize a habitat but that an analysis on the basis of groups of species shows promise.

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THE WEATHER IN 1961

E. W. May

Until the latter part of December the weather in 1961 promised to be notable for its open nature and general mildness but, in accordance with tradition, it was fickle to the end.

Rainfall

During the year total rainfall was below the long-term average, although the number of days on which rain fell was virtually the same as the average over the last fifteen years. The months of March and May were characterised by marked lack of rain. With one exception it was the driest March for fifteen years but, in contrast, April was the wettest for fifteen years. August was a wet month but was succeeded by a period of dry weather in September, October and November, when rainfall was below average. Snowfall during December caused the total precipitation for the month to be above the general average, but the amount actually falling as rain was below average. A total of 6″ of snow fell during December, 1″ during the first week, the remainder during the last three days of the month.

Sunshine

The total amount of sunshine recorded during the year was greater than the average. March and June were outstanding in this respect, the figure for March being exceeded only once during the past fifteen years. Despite higher than average rainfall, sunshine recorded during August proved greater than the long-term mean figure for the month. November, and surprisingly perhaps, December, both returned high sunshine figures which have been exceeded only twice over the last fifteen years. Most

dull weather occurred in January, February and April. April had the least sunshine for the month during the last fifteen years and July was also below average.

Temperature

Annual mean screen temperature was above the long-term figure for the area due to comparatively high temperatures during the early part of the year and in September. Mean monthly screen temperature for January was actually below average but that for February and March well above. Despite high rainfall and low sunshine levels April had above average mean temperature. Late frosts during May served to keep the temperature low. During July and August the mean screen temperature was below the average, repeating a tendency noticeable in 1960. Fine weather in September resulted in that month returning the highest monthly mean temperature of 1961.

The arrival of wintry weather in December ensured that temperatures were well below average. A noteworthy feature was the spell of spring-like conditions which occurred during the second week of the month when temperatures over 50°F were recorded. This contrasted sharply with the latter part of the month when daily maxima were of the order of 32°F or less.

Soil temperatures generally followed the trend of air temperature, annual mean figures showing little variation from those of the period 1946-1960. In late December the soil was frozen to a depth exceeding four inches for a period of six days. The last occasions on which there was a similar state of affairs were in February 1956 when temperature at 4″ depth was slightly below 32°F for a period of eight days, and in February 1954 when the temperature at 4″ depth was less than 32°F for a period of fifteen days, the lowest temperature reading being 28°F. The lowest temperature at this depth in December 1961 was 28.1°F.

Miscellaneous Phenomena

Fogs were most prevalent during the latter part of the year, notably December.

Air frosts were fewer than might have been expected during the early months of 1961, there being only one in February. Three air frosts occurred during the month of May, one with particularly severe effects on some crops. Ground frosts occurred once or more in each month except August. Again the month of May is of some notoriety since ground frost was recorded on thirteen occasions, compared with eleven in February and fourteen in November.

Table 1 illustrates some long-term comparisons.

Table 2 contains data which may be of more local concern.

TABLE 1

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
Rainfall (inches)	2.29	1.62	0.27	2.93	0.67	0.79	2.02	2.95	1.25	1.58	1.76	3.08	21.21
Rainfall as % of average 1916-1950	105	96	19	174	36	54	85	134	67	74	80	139	92
No. of times rainfall exceeded in previous 15 years	5	6	15	0	13	13	5	7	11	9	8	1	10
No. of rain days	17	14	6	19	8	12	16	18	8	19	13	16	166
Rain days as % average 1946-1960	113	110	46	171	66	89	129	130	59	147	87	103	103
Total sunshine (hours)	29.2	55.7	138.7	77.2	188.9	223.6	157.4	184.0	129.5	110.8	60.0	48.1	1403.1
Sunshine as % of average 1921-1950	71	94	129	55	107	117	87	109	105	115	112	150	103
No. of times sunshine exceeded in previous 15 years	11	10	1	15	5	3	8	4	6	3	2	2	3
Mean daily radiation (mw-hr. cm^{-2} day^{-1})	53	87	200	222	343	477	397	372	284	171	88	51	231
Temperature (°F)													
(1) Mean screen maximum	42.9	49.7	55.8	57.0	59.2	67.7	67.2	67.8	67.4	58.0	48.8	44.3	57.2
(2) Mean screen minimum	32.9	38.9	37.9	42.5	41.6	47.6	50.5	51.5	61.2	43.8	36.8	29.9	42.8
(3) Average of (1) and (2)	37.9	44.3	46.8	49.7	50.4	57.6	58.8	59.6	64.3	50.4	42.8	37.1	50
(4) Deviation from average 1921-1950	−0.5	+5.4	+4.6	+3.0	−1.6	0.0	−2.8	−0.9	+8.0	+0.8	−0.2	−2.3	+1.1
(5) Soil temperature at 4"	36.2	40.8	42.0	48.5	52.4	59.3	60.1	58.5	56.7	48.1	41.5	35.9	48.3
(6) Deviation from average 1946-1960	−1.0	+4.0	+2.6	+3.3	0.0	+0.7	−1.5	−1.6	+1.0	−1.1	−1.6	−3.6	+0.1
(7) Soil temperature at 2'	40.7	42.5	44.4	47.9	51.6	55.2	58.1	58.4	58.4	53.6	47.2	42.3	50
(8) Deviation from average 1946-1960	+0.1	+3.0	+2.8	+1.6	−0.1	−2.1	−2.8	−2.5	0.0	+0.6	−0.6	−0.8	−0.1

TABLE 2

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Highest Screen Maximum Temperature	55	58	68	63	72	83	78	85	80	66	58	57
Lowest Screen Maximum Temperature	34	41	43	48	52	55	57	60	59	49	42	27
Highest Screen Minimum Temperature	41	46	50	52	50	56	58	58	62	54	48	49
Lowest Screen Minimum Temperature	26	28	29	32	28	34	39	41	33	30	26	16
Lowest Grass Minimum Temperature	17	21	17	23	17	25	30	34	24	24	16	8
Most Rainfall in a day (9 hrs.—9 hrs.)	0.34	0.28	0.13	0.51	0.14	0.21	0.45	0.45	0.50	0.33	0.44	0.55
Number of days on which Fog occurred (9 hrs.)	1	0	2	1	0	0	0	0	0	4	6	9
Number of days on which Air Frost occurred	13	1	6	1	3	0	0	0	0	3	9	15
Number of days on which Ground Frost occurred	20	11	21	10	13	7	1	0	2	5	14	23

Temperatures recorded in degrees Fahrenheit

Rainfall recorded in inches

UNIVERSITY OF NOTTINGHAM
SCHOOL OF AGRICULTURE

PUBLICATIONS
1961

AGRICULTURAL BOTANY

E. J. M. KIRBY

Host-parasite relations in the Choke disease of grasses. *Trans. Brit. Mycol Soc.* **44**: 493-503. 1961.

Infection by *Epichloe typhina* induced no visible malformation of vegetative shoot apices of grasses but after floral initiation the apex became malformed and hyphae grew out abundantly. Extensive growth of mycelium occurred only when the flowering apex was between 2 and 10 mm. long. The formation of stroma and other disease symptoms is discussed in relation to the rates of growth of host and parasite during this stage. It is suggested that the vigorous growth of the fungus only at this stage occurs because this is the only tissue with sufficient meristematic cells in close juxtaposition for a sufficient time to allow the hyphae to absorb an adequate supply of nutrients.

F. L. MILTHORPE

The nature and analysis of competition between plants of different species. *Symp. Soc. Exp. Biol.* **15**: 330-55. 1961.

Competition between two or more species in the first year of growth can be analysed by comparing growth curves. Success or failure of a species depends on size of embryo, time of emergence, relative growth rate, and differences in maturity relative to other components; examples are given of systems in which each of these is important. Success in succeeding seasons depends on the number and size of survival organs (seeds, buds, tillers, etc.) produced during the first season, their dissemination in space and their growth relations. Whereas size of a plant and number of seed produced is approximately proportional to the available space, size of seed is remarkably constant. The influences of species on each other arise from modification of the nutrient, light and water environments of each individual; these are discussed in some detail.

F. L. MILTHORPE

Plant factors involved in transpiration. *Plant-water relationships in arid and semi-arid conditions. Proceedings of the Madrid symposium,* pp. 107-15. Unesco, Paris, 1961.

The important plant factors influencing transpiration are the stomatal conductance and the external resistance, which is a function of the degree and structure of the leaf cover (in the field) or the size and arrangement of leaves (in laboratory experiments). The sizes of conductances of various components in the vapour phase were examined; it is shown that those in the cell wall and in the substomatal cavities are extremely small. The interrelationships of the stomatal, cuticular and external conductances with discrete leaf surfaces and with extended areas of vegetation were explored.

W. J. WHITTINGTON and J. HILL

Growth studies on natural hybrids between *Lolium perenne* and *Festuca pratensis*. *J. exp. Bot.* **12**: 330-40. 1961.

The growth rates and chromosome numbers of plants taken from a natural population of hybrids between perennial rye grass and meadow fescue were determined. Growth rates of diploids resembled that of rye grass and of triploids that of meadow fescue. The persistence of the sterile hybrids is explained by recurrent formation and greater longevity due to growth characteristics intermediate between the parents which allow them to survive spring grazing more readily than meadow fescue and cutting for hay more readily than rye grass.

W. J. WHITTINGTON and W. E. PEAT

The behaviour of the Xasta (Xa) mutant of *D.melanogaster* in populations. *Drosophila Inform. Serv.* **34**, 110-111, 1960.

Using small plastic beakers as population cages it was shown that the Xasta mutant maintained itself in populations despite its lethality when homozygous. It was suggested that the Xasta heterozygote was favoured under competitive conditions and this hypothesis was supported by further studies. In particular it was found that the advantage depended upon the translocation and two inversions present in Xasta. It is likely, therefore, that the radiation treatment which induced the Xasta mutant also superimposed a translocation on two naturally occurring inversions and pre-conditioned the mutant to survive.

AGRICULTURAL CHEMISTRY

D. V. CRAWFORD

Trace elements and growth. *Research, Lond.* **14**: 342, 1961.

The infertility of some soils is due to the absence of traces of essential metals; their importance in the functioning of enzymes is discussed and illustrated by fuller consideration of molybdenum, manganese, copper and cobalt. Aluminium, too, may reduce productivity by its toxic action. There is no simple method of diagnosing crop or animal disorders arising from trace elements but some of the approaches employed are critically described.

D. GUTTRIDGE, D. LEWIS and J. T. MORGAN

Determination of the biological availability of methionine and cystine. *Nature, Lond.* **192**: 753-754. 1961.

It is known that methods of processing for example can influence the availability of amino acids in the food of farm animals. A method is described to determine the biological availability to the chick of the sulphur-containing amino acids. It is based upon measuring growth rate following supplementation of a specifically deficient basal ration with the material to be assayed. A basal ration containing soyabean meal is used.

D. LEWIS

Protein metabolism and nutrition. In *Nutrition of pigs and poultry* Ed. J. T. Morgan and D. Lewis. 43-56 (1961).

Developments in the nutrition of pigs and poultry can be made on the basis of knowledge of the fate of dietary constituents in the body: empirical excesses and arbitrary margins of safety can be eliminated, the implications of interrelationship can be precisely defined, the importance of balance can be specified, availability can be precisely expressed, and the effect of circumstances upon dietary requirement can be logically evaluated. The association of pathways of metabolism with nutrition can be exemplified by examining arginine and the chick. Arginine is an essential amino acid for the chick but there is some uncertainty regarding the quantity required in the diet. The differences are not related to availability or absorption but rather to features associated with the role of arginine and the balance of supply of arginine to other amino acids. Arginine is used for protein synthesis, for creatine synthesis and conversion to ornithine. Examination of these pathways of metabolism can clarify the uncertainty with regard to arginine in the nutrition of the chick.

E. R. LING (with S. K. KON and J. W. PORTER)

The composition of milk and the nutritive value of its components. S. K. Kon *and* A. T. Cowie *eds. Milk: the mammary gland and its secretion.* Vol. 2, Chap. 17. Academic Press, New York, 1961.

J. T. MORGAN and D. LEWIS

Ed. *Nutrition of pigs and poultry. Proc. Univ. Nottingham 8th Easter Sch. Agric. Sci.* Butterworths Scientific Publications, London (1961).

See article elsewhere in this volume.

AGRICULTURAL MICROBIOLOGY

M. J. CRUTCHLEY, A. SEAMAN and M. WOODBINE

Microbiological aspects of *Corynebacterium renale*. *Vet. Rev. Annot.* **7**: 1-9. 1961.

This organism is the cause of a specific cystitis and pyelonephritis in cattle and, to a lesser extent, in other animals (dogs, horses, goats, pigs and sheep). The review surveys the nature of the organism and disease; antibiotic sensitivity and possible treatment; biochemical aspects in relation to the powerful urease the organism produces. There is a bibliography of 68 references.

D. R. CULLIMORE and M. WOODBINE

A superior fat-synthesising single spore strain of *Lipomyces*. *Nature, Lond.* **190**: 1022-24. 1961.

This was an attempt to see if it was possible to improve fat-producing ability by selection of strains isolated as single spores. These single spore isolates of *Lipomyces* (10 strains) were provided by Dr. Catherine Roberts of the Carlsberg Laboratories and were of *L. lipofer* (7) and *L. starkeyi* (4). From the *L. starkeyi* it was possible to show that strains can be obtained with superiority in terms of sugar assimilation and/or fat synthetic ability.

J. W. HOPTON and M. WOODBINE

Fat synthesis by yeasts. 1. A comparative assessment of *Hansenula* spp. *J. appl. Bact.* **23**: 283-90. 1960. (1961).

Of 15 spp. comparatively examined, 7 gave good growth in relation to the sugar used and were divided into 3 categories in relation to fat content: those with *c* 20%, 13% and < 8%. In a medium containing urea as a N source, there was an initial phase—when most of the N was assimilated—and then a fat accretion phase.

SUSAN M. JONES and M. WOODBINE

Microbiological aspects of *Listeria monocytogenes*, with special reference to listeriosis in animals. *Vet. Rev. Annot.* **7**: 39-68. 1961.

This organism has, in the past, been regarded as pathogenic to animals, including man, causing a monocytosis. More recently, however, it has been implicated as a cause of repeated abortion in women. It is possible, therefore, that it should rank as one of the zoonoses. This timely review emphasises the animal aspects and refers to the organism; the disease in ruminants; as a cause of abortion; epidemiology; immunity aspects; antibiotics and chemotherapy; listeriosis in experimental animals; and concludes with an extensive bibliography of 270 references.

ROSEMARY J. PRINCE, A. SEAMAN and M. WOODBINE

The assessment of quaternary ammonium compounds in dairy hygiene. *Dairy Sci. Abstr.* **23**: 569-79. 1961.

These compounds are now permitted disinfectants for dairy and food hygiene. This review provides a general survey of the background studies and deals with their history; comparative assessment; applications; the surface versus suspension techniques and the effects of organic matter, chemical compounds, hardness of the water, pH, temperature, time, and different bacterial indicators on such techniques; mode of action, and practical uses. A selective bibliography of 136 references concludes the review.

J. D. IVINS

Reviews of some papers read at the 8th International Grassland Congress.—Grassland management and animal production. *J. Brit. Grassl. Soc.* **16**: 160-3, 1961.

The importance of stocking rate and animal potential is discussed in relation to techniques of research involving grassland management and particularly in connection with the interpretation of data of animal production.

The basis of animal production from grassland. *J. Yorks. Grassl. Soc.* No. 3: 5-12, 1961.

Factors influencing the yields of digestible feed, the proportion eaten by stock and the effects on animal production are discussed. Results of digestibility trials are given and their implications are considered in relation to animal production from grassland.

Autumn grass. *Agriculture, Lond.* **68**: 229-31, 1961

A possible explanation of the wide variability in animal production from autumn grass is suggested. Results of digestibility trials are given and the relationship between herbage digestibility and animal production is discussed. The factors influencing the variability in the digestibility of autumn herbage are also discussed.

D. M. ALLEN and G. E. LAMMING

Nutrition and reproduction in the ewe. *J. Agric. Sci.* **56**: 69-79. 1961.

An account of experiments to study how the plane of nutrition influences the reproductive cycle of the mature animals. When ewes in store condition were fed submaintenance diets the ovulation rate declined. When similar ewes were fed on a higher plane of nutrition for 5—8 days, 16 days or 30 days, there was a linear increase in ovulation rate but no further increase thereafter. The reproductive tracts, anterior pituitary, thyroid and adrenal glands were examined in ewes slaughtered 2—5 days post-oestrus. The effect of injection with P.M.S. was studied and it is suggested that nutrition affects ovarian activity not by any direct effect on the responsiveness of the ovaries to gonadotrophin but by regulating the rate of release of gonadotrophin from the anterior pituitary gland.

Some effects of nutrition on the growth and sexual development of ewe lambs. *J. Agric. Sci.* **57**: 87-95, 1961.

Studies were completed on the influence of high and moderate planes of nutrition on the growth and sexual development of ewe lambs. Puberty occurred earlier but at higher body weights in high-plane lambs. However, the plane of nutrition did not affect the ovulation rate or the number of large follicles in the ovaries. The lower plane of nutrition resulted in an increase in the size of the adrenal cortex but no significant changes in the other endocrine glands examined.

W. R. SHORTHOSE and G. E. LAMMING

The effect of implanting testosterone alone or with oestradiol on the growth rate and carcass quality of fattening female hoggets. *Anim. Prod.* **3**: 97-102, 1961.

Female hoggets from 5 to 7 months of age were implanted with 15 or 30 mg. testosterone proprionate or with 2.5 mg. oestradiol benzoate plus 25 mg. testosterone proprionate. No significant effects could be shown on the average daily gain, carcass yield, carcass score or the proportion of retail cuts.

The effect of different oestrogens and oestradiol plus progesterone on the growth and carcass characteristics of fattening male hoggets. *Anim. Prod.* **3**: 183-193, 1961.

Using five flocks with a total of 473 sheep the effects of diethylstilboestrol paste, oestradiol plus progesterone implants and hexoestrol implants were compared. Where the plane of nutrition was high, all hormone treatments resulted in significant increases in liveweight gain, with extra carcass weight, extra pelt weight, but no change in the killing-out percentage or carcass grade. In two flocks the diethylstilboestrol paste showed initial extra liveweight gain compared to the other products. Where the plane of nutrition was low there was no significant effect of hormone treatment.

R. A. COSTAIN and J. T. MORGAN

The effect of variations in the energy and protein status of the diet upon productive efficiency in the pig. *Anim. Prod.* **3**: 199-208, 1961.

The results of trials involving differential energy and protein levels on growth rates, food conversion and carcass quality of bacon pigs are reported and their implications on feeding practice are discussed.

*G. A. LODGE (and R. M. MacPHERSON)

Level of feeding during early life and the subsequent reproductive performance of sows. *Anim. Prod.* **3**: 19-28, 1961.

Gilts from weaning to 200 lb. liveweight were fed either according to a scale rising to 8 lb. meal per day, or 80% of that level, or 60% of that level or changed from the low to the medium plane at 14 weeks of age. Thereafter all were treated the same for three pregnancies and lactations. Level of feeding affected significantly growth rate from weaning to 200 lb. but did not affect age at puberty nor the subsequent reproductive performance of those animals which were fertile.

*G. A. LODGE, (I. McDONALD and R. M. MacPHERSON)

Further observations on the relative influence of birth weight and creep-feed consumption on the 3- and 8-week weights of sucking pigs. *Anim. Prod.* **3**: 261-267, 1961.

Data relating to the first 3 litters from each of 21 Wessex Saddleback sows, all by the same Large White boar, were analysed on within litter, between litter/within sow, and between litter/between sow bases. There were highly significant differences between sows in the weights of their pigs at birth, 3 and 8 weeks of age but not between litters of the same sow. Number born but not number weaned increased significantly from first to third litters. The percentage of variation in weight accounted for by variation in birth weight was considerably less at 8 weeks than at 3 weeks and less between litters than within litters. Difference in creep-feed consumption accounted for 36% of the difference between litters in 8-week weight.

*G. A. LODGE, (I. McDONALD and R. M. MacPHERSON)

Weight changes in sows during pregnancy and lactation. *Anim. Prod.* **3**: 269-275, 1961.

Data collected from a total of 50 Wessex Saddleback sows during the production of one to 4 litters each, indicated that checks to weight increase occur at specific stages of pregnancy, that most of the weight gain during pregnancy which is not accounted for by litter and placenta is lost before the next pregnancy, that considerable loss in weight normally occurs between weaning and re-mating, and that this post-weaning loss is greater in sows which have been fed to maintain weight during lactation than in those allowed to lose weight during lactation.

*G. A. LODGE

The nutrition of the lactating sow. *Proc. Univ. Nottingham 8th Easter School Agric. Sci.* (1961.) 221-234.

Estimates of the requirement of the lactating sow for energy, protein, minerals and vitamins may be made from published data on yield and composition of sow's milk. Such estimates for energy requirement indicate the need for a greater meal allowance than is commonly recommended and their validity depends on whether the appetite of the sow is sufficiently great to allow high food intakes, whether it is desirable that weight loss should be prevented, and whether it is desirable that the sow should produce her maximum possible yield throughout lactation. Consideration of the relevant published data indicates that direct provision of nutrients during lactation would allow more efficient utilisation than indirect provision and storage during pregnancy.

*(I. A. M. LUCAS and) G. A. LODGE

The nutrition of the young pig. Commonwealth Bur. Anim. Nutrit. Tech. Comm. No. 22, 119.

A review of present knowledge on the nutrition of the young pig from birth to approximately 8 weeks of age.

* Research work carried out at the Rowett Research Institute.

G. A. LODGE

How much meal for in-pig sows? *Pig Fmg.* **9** (2): 26-27, 1961.

A review of published information on the total feed requirements of the pregnant sow.

G. A. LODGE

Feeding the in-pig sow. *Pig Fmg.* **9** (3): 41-45, 1961.

A review of published information on the requirement of the pregnant sow for protein, minerals and vitamins.

G. A. LODGE

Feeding the pregnant sow. *Irish Frms' J.*, **13** (8): 11, 1961.

A review of published information on the nutritional requirements of the pregnant sow.

G. A. LODGE

Feeding the early-weaned pig. *Pig Prod.*, March 1961, 29.

The nutritional requirements of pigs weaned at 2, 10 or 35 days of age.

C. G. PAYNE

Colour and density of light and broiler performance. *Nature, Lond.* **192**: 769-770, 1961.

In littered environmental chambers, a reduction in the light intensity from 0.20 to 0.05 foot candles, during the first week after hatch, reduced food and water consumption and increased chick mortality. In the latter period of fattening to 70 days of age, the duller lighting was associated with improved food utilisation.

Studies on the climate of broiler house: Air movement. *Brit. Vet. J.*, **117**: 36-43, 1961.

With 10-week old broilers, at 60°F air speeds above 70 feet per minute caused overcrowding and losses due to smothering. At 70°F air speeds of 150 feet per minute had no effect. Alterations in the design of air inlets affected air velocities at floor level by up to nine hundred per cent.

Studies on the climate of broiler houses: comparison of ventilation systems. *Brit. Vet. J.*, **117**, 106-114, 1961.

The results suggest that maximum ventilation rates for summer equivalent to 3.0—4.0 cu. ft. per broiler are a satisfactory basis for calculating ventilation requirements. Air inlets of suitable design to prevent draughts at floor level, which provided 0.6 to 1.0 square inches of inlet per bird were ideal. Where the air inlet velocity through baffled inlets was less than 250 feet per minute fluctuating winds caused variable ventilation rates due to cross ventilation.

R. W. RADLEY, M. A. TAHA and P. M. BREMNER

Tuber bulking in the potato crop. *Nature, Lond.* **191**: 782-3, 1961.

Yield in the potato crop is determined by the rate and duration of tuber bulking, the latter being a function of the time of tuber initiation and the persistence of foliage. The relative importance of these factors in determining yield differences between varieties and times of planting is discussed. The bulking rates of the varieties here studied did not differ much, and the duration of the bulking period was the more important yield determinant; bulking rate was, however, depressed by early planting (March 28th) as compared with late planting (April 13th), and played a significant part in determining yield.

HORTICULTURE

J. P. HUDSON

Need bad weather mean poor crops? *New Scientist*, **9**: 142-4, 1961.

The effects of bad weather on agricultural and horticultural crops are well known. The control of plant behaviour by using chemical regulators is discussed as a means of reducing the effects of adverse climatic conditions on crop yields.

Small scale farming on the Nile. *Golden Sheaf*, **11**: 33-5, 1961.

Methods of crop production are discussed in relation to the level of the land above the river and problems of irrigation.

Weather, crops and man. *Rur. Stud. J.*, **6**: 12-18, 1961.

A sound training gives you a wide choice. *Grower*, **55**: 181, 1961.

Different types of training for potential horticulturists are discussed.

J. P. HUDSON and D. W. T. CLAY

Tomaten en zout. *De tuinderij*, **1**: 438-40, 1961.

Describes Sutton Bonington work on the effects of high levels of soil salinity on yields and quality of glasshouse tomatoes.

J. P. HUDSON and I. H. WILLIAMS

Effects of environment and age on flowering in raspberries. *Proc. Linn. Soc. Lond.* **172** Session: 101-8. 1961.

The phases of development through which each shoot of a raspberry plant passes are discussed in relation to climatic conditions.

W. HEYDECKER

Horticulture. In *Britannica Book of the Year*, 1960.

A review of highlights and developments in British and Commonwealth horticulture—political, economic and technical.

Review of *Japanese Potassium Symposium* (International Potash Institute, Bern, Switzerland) 1959 in *Landw. Forsch.*, **14**: 1961.

WINIFRED M. DULLFORCE

New lettuce varieties on trial. *Grower*, **56**: 382-4, 1961.

The results of two years' experiments with four new winter glasshouse lettuce varieties as compared with the standard variety, Cheshunt 5b, showing that differences in behaviour may be explained on the basis of the concepts of growth analysis.

AGRICULTURAL ECONOMICS

GWYN E. JONES

The Merchant's contribution to agricultural progress. *J. Inst. Corn Agric. Merch.*, **9**: 99-103, 1961.

Shows the function and relative importance of the agricultural merchant in providing farmers with information which is necessary during the process of deciding whether to adopt or reject farming innovations. On the basis of an empirical study merchants are shown to be of varying importance as sources of information according to different innovations. A hypothesis is proposed that the importance of merchants' advice increases during the adoption process. Since agricultural merchants are undoubtedly important in providing farmers with information and advice, a closer liaison between them and the N.A.A.S. is suggested.

R. BENNETT JONES and GWYN E. JONES

Systems of beef rearing and fattening: three examples. (University of Nottingham, F.R. No. 143) 1961.

This report presents three case studies of the costs and returns of rearing and fattening beef stock. The management is considered to be of a high order on each farm, but each practises different rearing and feeding systems. Other factors, such as the price of bought calves and mortality, also materially affect the final margin. It is concluded that beef production remains a somewhat speculative enterprise.

T. K. WARLEY

The impact of European economic integration on British agriculture and the Commonwealth (University of Nottingham). 1961.

This report begins with a review of the economic and political importance of the agricultural sector in the European Economic Community: of the essential features of the proposed common agricultural policy: and of trends in domestic food consumption and production and net trade in temperate agricultural products in the Six.

It is suggested that although the position of British agriculture under the common agricultural policy of the Six would be less secure and possibly less profitable than under present support arrangements, despite broad comparability in product price levels and substantial advantages in farm structure and productivity, the future of the industry if outside the E.E.C. is even more uncertain and problematical due to the likely breakdown of current domestic income support policies.

On the other hand, the study concludes that the economic and political consequences of Britain having to abandon her trading arrangements with Commonwealth countries constitute the most substantial obstacle to Britain's adherence to the Rome Treaty: that disruption of the Commonwealth as a political entity would be too high a price to pay for European unity: that Britain is unlikely to suffer substantial or irreparable harm if she does not join: and that her best course would be to work for multilateral tariff reductions within the G.A.T.T. rather than on a narrow European front.

DEPARTMENTAL PUBLICATION

Farm Management Notes. Nos. 25 and 26, Spring and Autumn, 1961.

This publication is issued twice yearly to over 1,200 farmers, advisory officers, British and foreign administrative agencies, educational institutions and libraries. Short articles make available to the farming industry the facts, ideas and suggestions which arise from the research and advisory work conducted by members of the Department of Agricultural Economics.

LECTURES AND PAPERS—1961

P. M. BREMNER:

'Self-sufficiency in farming' to Underwood Farmers' Discussion Group.

'Cereal production' to Lincolnshire Farming Conference.

D. K. BRITTON:

'The Common Market and the young farmer' to the Northern Area Committee, National Federation of Y.F. Clubs.

'Productivity, grassland and the British farmer' to a N.A.A.S. meeting at Brackenhurst.

'The common market and British farming' to the Harrington Agricultural Discussion Society.

'The common market' to the Queniborough and District Y.F.C.

'Agriculture and the common market' to the South Notts. Branch of the N.F.U.

'The future of the small farmer in Europe' to the Ashover Farmers' Club.

R. L. BURT:

'Some effects of temperature on the growth and development of the potato' to the European Association for Potato Research at Wageningen.

J. CHATTERTON:

'Mechanisation on the University farms' to Horncastle Machinery Club, Horncastle, Lincs.

D. V. CRAWFORD:

3 Lectures on 'Soils and Archæology' to the University of Nottingham Department of Extra-Mural Studies course on 'Scientific Techniques and Archæology'.

R. D. HARKESS:

'Modern grassland trends' to Kettering Agricultural Discussion Club.

'Pasture quality and grazing systems' to N.A.A.S. Conference, Helston, Cornwall.

W. HEYDECKER:

'Recent developments at the University of Nottingham Department of Horticulture' to Leicestershire Commercial Horticultural Discussion Society.

'Producing a stand of seedlings' to Hampton and Staines District Growers' Club.

J. P. HUDSON:

'Plants and their environment' to the Faculty of Agriculture, University of Khartoum.

J. D. IVINS:

'Grassland production and utilisation' to Cheshire Farm Institute Conference.

'Increases in animal production from grassland' to Weston (Cheshire) Discussion Society.

'Basic principles of grass utilisation' to N.A.A.S. Conference, Melton Mowbray.

'Grass and the grazing animal' to N.A.A.S. Conference, Shrewsbury.

'Science and Agriculture' to Scientific and Technological Committee of the National Council of Women in Great Britain.

'Grass utilisation' to Market Harborough Farmers' Discussion Group.

'Herbage digestibility and animal production' to Harper Adams Agricultural College, Newport, Shropshire.

'The nutritive value of herbage' to Grantham N.F.U. Conference.

'Changes in the concept of good husbandry' to Chartered Land Agents' Society, at School of Agriculture, Sutton Bonington.

'Grassland evaluation' to "Grasshoppers" Discussion Group, Salisbury.

'Advances in grassland thought and practice' to Car Colston and District Farmers' Discussion Society.

'Grassland Productivity' to Ministry of Agriculture N.A.A.S. Officers' Course, Harrogate.

'Grass utilisation' to Edenham and District Farmers' Discussion Group.

'Grassland management and animal production'—University of Bristol Extra-Mural lecture.

J. D. IVINS and R. W. RADLEY:

'Research in potato agronomy' to National Association of Seed Potato Merchants.

GWYN E. JONES:

'Sociological factors affecting agricultural progress' to the British Association for the Advancement of Science, Annual Meeting, Norwich.

R. BENNETT JONES:

'The future of small farms in the United Kingdom' to Underwood and Selston Discussion Group.

'How to plan for profit' to Fosse Farmers' Club.

'Cost information for farm management' to Institute of Cost and Works Accountants, Derby.

'The work of the P.A.E.S.' at Leicestershire and Rutland Farm Institute.

'Analysis of the farm business' to Chartered Land Agents' Society at School of Agriculture, Sutton Bonington.

G. E. LAMMING:

'Hormones in meat production' to University of Bristol Veterinary School.

'What's happening in livestock' to Edenham Farmers' Discussion Society.

'Farming in America' to Peterborough Farmers' Club.

'Use of hormones to control the fertility of farm animals' to Royal Society of Medicine, Section of Comparative Medicine, London.

'British Agriculture' to Derby N.F.U.

'Education and research in Agriculture' to Shepshed Rotary Club.

'Research in sheep breeding' to National Sheep Breeders' Association.

'The influence of ovarian hormones on uterine infection' to Society of Fertility and Reproduction, Cambridge.

'The physiology of growth' to the Agricultural Institute, Dublin.

3 Television programmes on 'American Agriculture' for the B.B.C.

'Modern methods of producing quality meat' to the Institute of Meat, Inauguration Meeting of the Birmingham Branch.

G. E. LAMMING and R. B. HEAP:

'The influence of ovarian hormones on the chemical composition of uterine secretions' to the 4th International Congress on Reproduction at The Hague, Holland.

D. LEWIS:

'Protein metabolism and nutrition' to the University of Nottingham 8th Easter School in Agricultural Science at Sutton Bonington.

G. A. LODGE:

'Nutrition of the lactating sow' to the University of Nottingham 8th Easter School in Agricultural Science at Sutton Bonington.

'Research and improved pig production' to a Farmers' Conference by P.I.D.A. and N.A.A.S. at Norwich.

'The feeding of breeding stock' to Symposium on Pig Nutrition by the Institute of Corn and Agricultural Merchants at Harper Adams Agricultural College.

'The feeding and management of pigs' to Farmers' Conference by N.A.A.S. and British Association of Pig Producers' at Basingstoke.

'Pig feeding in 1961' to Farmers' Conference, Somerset Farm Institute.

'Producing the pig' to Symposium on Marketing the British Pig by Bengers Laboratories Ltd. at the Royal Dairy Show.

'Recent developments in the feeding and management of the breeding sow' to Farmers' Conference by G. W. Plowman & Son Ltd., Spalding.

'Weaner Production' to Conference on Prime Pork Production by Spillers Ltd., Nuneaton.

MARGARET E. MARSTON:

'Horticulture at a University' to Horticultural Education Association at Bedford.

F. L. MILTHORPE:

'Leaf growth in relation to incident radiation' to the Association of Applied Biologists at Rothamsted.

'The relative importance of various physiological processes in determining yield' to the Symposium of the Institut für Pflanzenzüchtung at Gross-Lüsewitz.

'Physiological components influencing the yield of grass' at the Grassland Research Institute.

J. T. MORGAN:

'Recent developments in pig nutrition' to Bedford Pedigree Pig Breeders' Association.

J. T. MORGAN and D. W. ROBINSON:

'Dietary factors and the performance of growing/finishing pigs' to University of Nottingham 8th Easter School in Agricultural Science at Sutton Bonington.

J. A. H. NICHOLSON:

'Improved profits and management' to Derby and District Horticultural Growers' Discussion Society.

C. G. PAYNE:

'Influence of climatic environment on poultry performance' to University of Nottingham 8th Easter School in Agricultural Science at Sutton Bonington.

'Intensive poultry housing' to N.A.A.S. Conference at Banbury.

'Turkey housing' to British Turkey Federation meetings at Colchester and York.

'Recent developments in environmental management' to N.A.A.S. Conference at Liphook, Hants.

'Housing poultry breeding stock' to N.A.A.S. Conference at Banbury.

'Problems in intensive poultry housing' to Leicestershire and Rutland Farm Institute.

J. H. D. PRESCOTT:

'Feeding the pig' to Farmers' Meeting, Boston, sponsored by Messrs. Smith, Kline & French Ltd.

W. S. SENIOR:

'Economics of egg production, future and present trends' at the Huddersfield College of Technology.

'Economics of egg production, present position and future prospects' to the Chick Producers' Association, Annual Refresher Course.

T. W. D. THEOPHILUS:

'Reducing costs' to the Technical Development Session of the N.A.A.S. Executive Committee, Sleaford.

'The economic outlook and prospects for British agriculture' to the Oundle and District Agricultural Discussion Society.

'Reducing costs and maintaining profits without increasing output' to the Northants. Agricultural Education Committee, Institute of Agriculture, Moulton.

'The opportunities for cost reduction on the farm' to the Metheringham Farmers' Discussion Group.

'Analysing farm accounts and budgeting'—Three lectures to a small farmers group at Sleaford.

'Programme planning' to the N.A.A.S. County Staff Meeting, Sleaford.

'Programme planning' to the N.A.A.S. District Advisory Officers, Derby.

'The future of British agriculture' to the Ayrshire Cattle Breeders' Society at Brackenhurst.

'Programme planning and its implications' to the N.A.A.S. Staff Meeting, Nottingham.

'The economics of beef production' to the Alford Discussion Society.

'Farm management' to the Alfreton Agricultural Discussion Society.

'Records for farm management' to the Selston and Underwood Discussion Society.

'Records for management purposes' to the Productivity Discussion Group, Bakewell.

'Economics of milk production' to the Milk Production Group, Rutland.

'The outlook for British farming' to the Alfreton Agricultural Discussion Group.

'The future of farm management advisory work'—East Midlands N.A.A.S. Course.

'Planning for profits' to the N.A.A.S., Sleaford.

'Credit in agriculture' to the Market Rasen Y.F.C.

T. K. WARLEY:

'Time and motion study' to the Derby and District Y.F.C.

'Trends in horticultural marketing' to a group of North Notts. farmers.

'The economics of tomato production'—Two lectures at Riseholme Farm Institute.

'The impact of European economic integration on British and Commonwealth agriculture' to the National Association of N.F.U. Group Secretaries.

'A critique of current British agricultural policy with special reference to the association of Britain with the European Economic Community' to the Warwicks. and Staffs. N.F.U. County Delegates.

'The common market' to the Aston Cantlow Farmers' Club.

'Management in horticulture' to the 3rd Askham Bryan Horticultural Conference.

'The common market' to the Cheshire Province of the Institute of Corn and Agricultural Merchants.

'The common market and its implication for British agriculture' to the Institute of Corn and Agricultural Merchants, Ashbourne.

'The economic basis of United Kingdom agricultural income support policies'—Seminar at the Agricultural Economics Research Institute, Oxford.

W. J. WHITTINGTON:

'Genetical analysis of growth in the tomato' to the Genetical Society at Sutton Bonington.

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'Geneticists and You' to the Nottingham University Biological Society.

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